MAINTENANCE ENGINEERING

In Plants, Mills, and Factories

IN THESE days of lifting via bootstraps, there is glib talk of spending money to make money. But bearing much truth.

We have cited recently: Investment $3,000, annual saving $1,700. Annual saving $8,100—31% on investment. Saving $8,287—annual return 165%. Investment $1,200—$2,160 saved in two years. And others.

In many plants similar investments can be made, even on the basis of today's reduced output. That's spending money to make money. It's rehabilitation.

McGraw-Hill Publishing Company, Inc.

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DECEMBER

1932

For contents, see page 472

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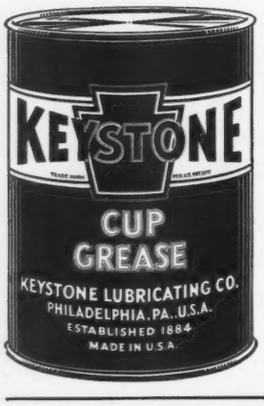

Keystone Cup Grease is also available in extra soft and extra hard densities

KEYSTONE LUBRICATING COMPANY
21st, Clearfield and Lippincott Sts., Philadelphia. Est. 1884

KEYSTONE LUBRICANTS

Your Keystone Distributor will be glad to supply you with further information, or a trial order of Keystone Cup Grease.

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MAINTENANCE ENGINEERING

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DECEMBER
1 9 3 2

Synchronized Mechanical Motion Without Mechanical Connection

C. W. DRAKE
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MANY PRODUCTION machines have developed from a single or simple element into a complex group consisting of many parts definitely correlated as one operating unit. Sometimes the various sections of a unit may extend over a length of several hundred feet; in other cases the sections may be on different floors, or in almost any relative position. It is evident that in many cases the mechanical transmission required, such as shafting, chains, gears, to connect the various sections together in a positive relation becomes complex and comparatively expensive. If one section of the unit is movable or adjustable, splined shafts may be required and in order to cut a section in or out a friction or jaw clutch is necessary.

It is not surprising that when looking for opportunities to simplify drives, reduce maintenance, and improve performance, some better method was sought of operating these auxiliary or coordinated drives.

What is known as the "Synchro-Tie" system utilizes electric motors at the transmitting and receiving ends and copper wires in place of shafting. Figure 1 shows the fundamental connections of such a system in which *A* and *B* are identical wound-rotor induction motors, with their primary windings connected to the a.c. supply and their rotor windings connected together. When the rotors are connected in proper phase relation the secondary voltages will be equal and opposite, so that no current will flow through the rotors; consequently there will be no tendency to rotate or develop torque.

Assume now that motor *A* is turned a small amount, even 5 or 10 mechanical degrees. The rotor voltages are no longer opposite and equal; a small difference in voltage is produced, causing a current to flow which in turn develops torque and tends to bring the rotor of motor *B* into the same position as that of machine *A*. If *A* is rotated continuously, *B* will rotate at exactly the same speed, assuming that it is of sufficient capacity to drive the machine to which it is connected. Between the two machines there will always be a small angular or phase difference which is necessary to circulate the load current, but this might be compared to the torsion of a shaft, which varies with the load. The two machines are always revolving at exactly the same speed and in synchronism, and for a given load there will be no change in the angular position of the two rotors.

The characteristics of wound-rotor motors connected in this manner make it possible to use this system in place of positive, mechanical drives, with numerous advantages in installation and operation. Assume that machine *A* in Fig. 1 is coupled to a 20-hp., 300/900-r.p.m., d.c. motor that drives a certain machine requiring a 3:1 speed range, in connection with which is a conveying system that must operate at a speed exactly proportional to the main machine. Closing the line-starter with all machines at rest causes *A* and *B* to assume a synchronous relation; then as the controller on machine *C* is operated, motor *B* gives exactly the same performance on the conveyor or whatever it may be driving as though it were mechanically connected to the main drive. During normal operation of motor *C* the Synchro-Tie system remains connected to the a.c. supply and although at standstill there is no ventilation, the current taken is also reduced to approximately the excitation current so that a safe temperature is seldom exceeded.

Wound-rotor motors used in this manner naturally have different characteristics than when used individually. One of the first requisites is that the maximum speed at which the motor is operated should not be much above 75 per cent of its synchronous speed, if a reasonable amount of tor-

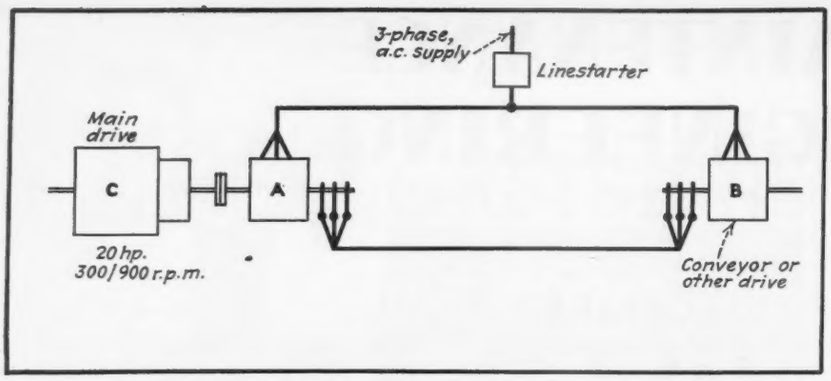


Fig. 1—Fundamentally, a Synchro-Tie system comprises two wound-rotor motors, "A" and "B," with the stators excited from a three-phase supply and the rotors connected electrically, but not mechanically. When the rotor of motor "A" is driven mechanically by the main drive motor "C" the rotor of "B" turns in synchronism with it.

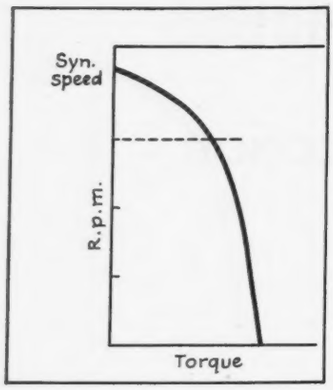


Fig. 2 — Speed - torque curve of wound-rotor motors connected in synchronous relation.

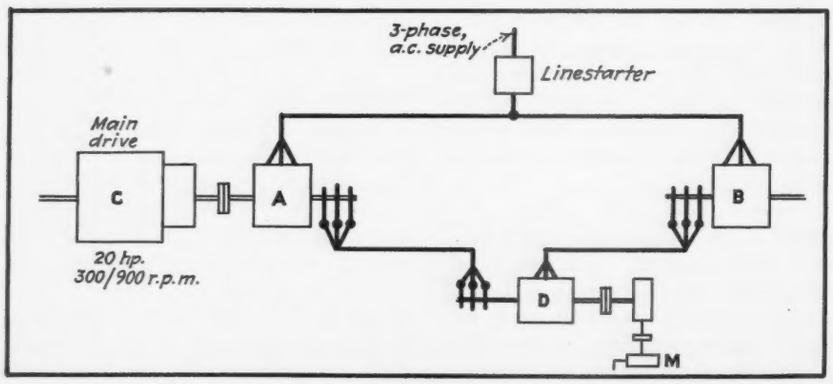


Fig. 3—Inclusion of an electrical differential or phase advancer, "D," in the system makes it possible to change the relation between the positions of the rotors of motors "A" and "B."

que is desired. It is assumed that the motor is driven in the same direction as it would normally operate as a motor. Figure 2 shows the characteristic relation between the speed and maximum torque obtainable when connected as shown. In the example illustrated in Fig. 1 six-pole, 1,200-r.p.m. motors would be used on a 60-cycle circuit, whereas if the speed of the d.c. motor were 1,000 or 1,200 r.p.m. it would be necessary to use four-pole, 1,800-r.p.m. motors.

When connecting machines *A* and *B* together by closing the a.c. switch it is necessary that both be at a standstill, the same as though a jaw clutch were used on a mechanical transmission. If it is desirable to start and stop the conveyor driven by motor *B* while motor *C* is running, it can best be accomplished by using a magnetic clutch on *B*, in which case *B* will run light but always in synchronism with *A* and *C*.

It is evident that since the motors are operating below their normal speeds the horsepower output also will be reduced. In determining the size of motor required it is necessary to consider other factors such as the starting torque required, the rate of acceleration (which is determined by the main motor) and dynamic braking or rapid deceleration.

Numerous modifications of the simple Synchro-Tie system outlined above are possible to meet special requirements. In the case of the two machines in Fig. 1, for instance, it may be essential to have a definite position or phase relation between the main machine and the conveyor, and from time to time it may be necessary to change or adjust this relation. With a mechanical drive a differential can be worked into the transmission so that the position of the conveyor may be advanced or retarded as desired without affecting the driving speed after the change is made.

An exactly similar result can be obtained electrically by the introduction of what may be termed an electrical differential into the fundamental circuit shown in Fig. 1. In Fig. 3 is shown such a differential, *D*, which consists of a wound-rotor motor of the same capacity as *A* and *B* connected to a high-ratio gear and driven by a small motor *M*. Consider *D* as rotating at a low speed; then since *B* is of much smaller capacity than *C* (the main drive), the speed of *B* and hence of the conveyor, will be increased by an amount corresponding to the motion of *D*. The change in speed occurs only so long as *M* is operated and by using a high gear ratio it is possible to obtain close control of the speed and also use a small driving motor. As the differential is entirely electrical it may be placed in any desirable location, not necessarily near the machine. Various modifications of the differential unit are possible to provide special features, such as a variable ratio between *A* and *B* by running the differential constantly but at varying speeds; however all such problems require a careful analysis of the conditions to be met.

An interesting application utilizing a continuously running phase advancer is illustrated in Fig. 4. Here a two-drum, 900-ft.-per-min. winder is connected synchronously to a 160-in., ten-roll calender and the required tension on the paper is determined by the speed at which the phase advancer, Fig. 5, operates. More information regarding this interesting drive is given in the *Paper Trade Journal*, February 18, 1932, issue.

Variable-voltage direct current is commonly used where varying speed

control is required over a considerable range and frequently several motors are operated in parallel from the same generator and drive different parts of the same machine. In Fig. 6, *A*, *B*, and *C* represent three d.c. motors driving sections of a machine; *X*, *Y* and *Z* are wound-rotor motors of identical design coupled to the main driving motors. Speed control of the entire machine is by means of the variable voltage delivered by the main generator, but the wound-rotor motors hold all sections together as though connected by gears to a lineshaft. It is necessary, of course, that the wound-rotor motors be suitably chosen to take care of any unbalanced loads that may occur. In a connection like this any motor may become a generator or a motor, depending upon load conditions. By selecting a.c. motors of suitable size they may even carry the entire load of a section in case of failure of the d.c. motor, although this would require large excess capacity for normal operation.

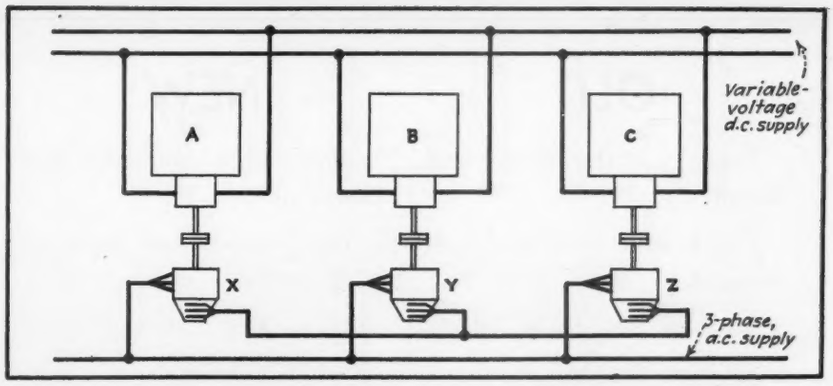


Fig. 6—Multiple-unit, variable-voltage drive with parallel arrangement of Synchro-Tie units.

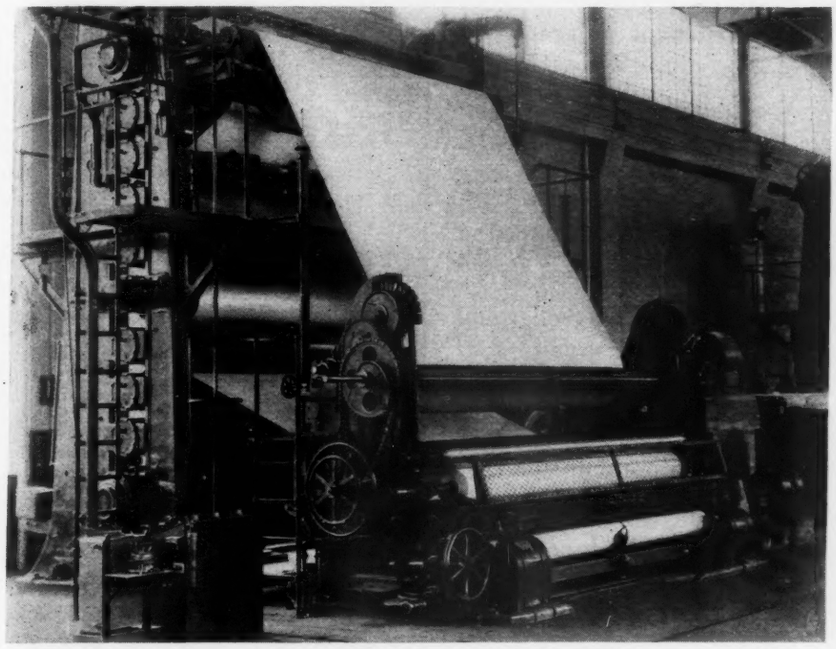


Fig. 4—Two-drum, 160-in. paper winder operating at 900 ft. per min. driven by a Synchro-Tie motor in connection with the phase advancer shown in Fig. 5.

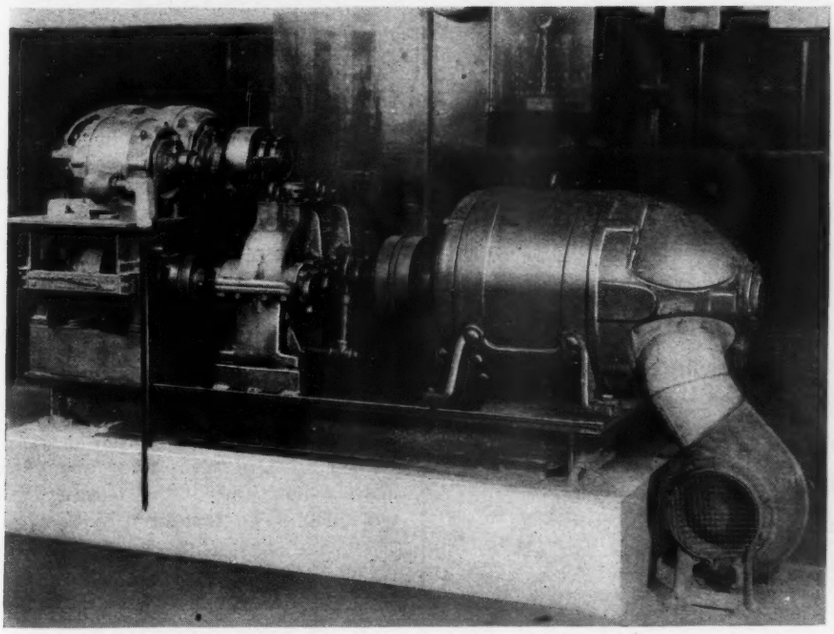


Fig. 5—Continuous-duty phase advancer for paper winder drive, providing special features of inching, variable ratio, and forced ventilation.

■

Two Indexes Coming

BOUND into the editorial section of the next (January) issue will be the Index of Equipment, listing the new and improved machines and devices, and other shop equipment described in *Maintenance Engineering* as they were placed on the market during the year 1932.

* * *

Available separately, about the middle of February, for distribution free upon request, will be the Index of Editorial Contents of the twelve issues of 1932. Requests received now will be filed, and will be honored just as soon as the index has been printed.

* * *

Coming, also, more on the overhead conveyor. This time the matters of design, cost, and installation are taken up. Economical handling ties in directly with rehabilitation and the necessity for analytical examination of equipment before purchase and installation. Practically every overhead chain conveyor installation is a custom-built job. The time is ripe in many plants to settle the details in readiness for resumed production.

OLD	NEW
Four-story building and basement	Single-story building and basement
Check room and toolroom separate	Check room and toolroom combined
Elevator and truck service requirements extensive	Elevator and truck service requirements slight
Machine shop on first floor, perforating department on third floor	Machine shop and perforating department adjacent, on first floor
Sheet-metal shop in another part of town	Sheet metal shop on first floor
Twenty per cent of mild steel stock duplicated in sheet metal and machine shops	Central stock room for both departments, stock duplication eliminated
Three floors lighted from windows only	Entire plant receives light from windows and monitor roof
Perforating dies made under artificial light	Perforating dies made under natural light — 25 per cent of former trouble eliminated
Hardwood floors	End-grain, creosoted wood blocks. Concrete floor in basement, with wood-block trucking aisles
Assembly on third floor, ceiling height 6 in. less than height of tallest machine	Assembly on first floor, ample ceiling height

ADDITIONAL FEATURES IN THE NEW BUILDING

Ten-ton crane serves main bay of entire first floor

Six-ton elevator between first floor and basement

Two 8x16-ft. crane-service trapdoors in floor of main bay

Trapdoor between machine shop and heating plant, permitting transfer of newly built coal pulverizers for testing

Dumbwaiters between shops and storerooms

Monorails for receiving goods, for outbound shipments, connecting shipping rooms, in basement storeroom

Dust-collecting system in wood shop

Forced draft ventilation in office

Electrically cooled drinking fountains

Fountain-type circular wash bowls

Automatic call system

Twenty-car garage with wash rack

Building Fe

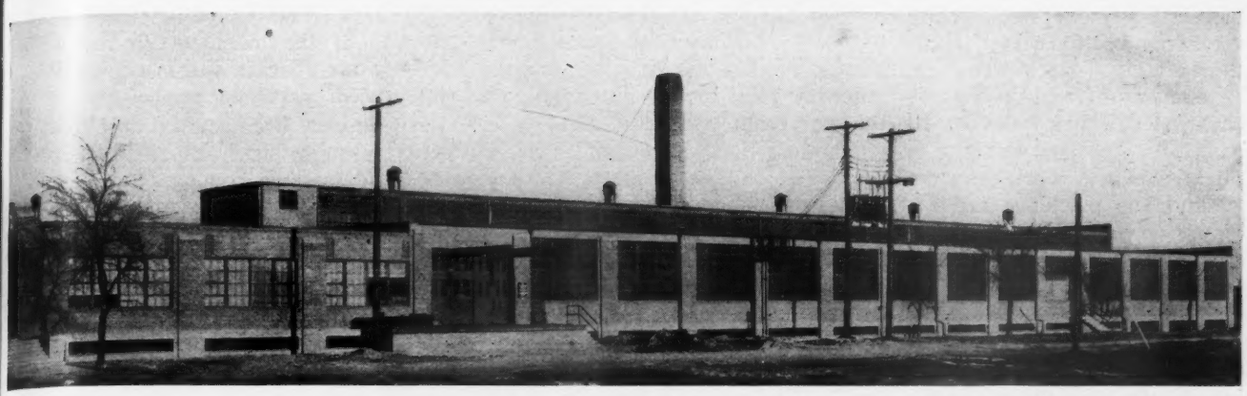
TWENTY years' operation in a four-story building with a basement convinced our company that a factory with all operations on one floor would be best adapted to its needs in the manufacture of flour milling, grain handling, and coal pulverizing equipment. The experience gained in its 34 years of machinery manufacturing indicated clearly the superiority of a one-floor plant for its business.

Accordingly the new home is designed essentially to fill this need for a one-story building; but, because of the necessity to excavate to a depth of 12 ft. to reach bearing soil under the peat deposit which occupied the site, it was more economical to finish and use the basement than to fill it in. Therefore some of the departments are on the lower level.

Light wells and large windows furnish ventilation and light for the wood shop in the basement. In summer, working conditions there are better than those upstairs because it is much cooler in the basement. The stock room, warehouse, boiler room, and garage also occupy space in the basement.

What it means to the machine shop foreman to have practically all of the operations on one floor can be realized by recalling the fact that in the old building there was always a chance that some of the details of the work would be forgotten by the time the last floor was reached. Now the checking is done in half the time previously necessary.

In the old building the check room was on the first floor under supervision of the toolmaker. Now the



West elevation of the plant. Note large window area, mechanical ventilators on the roof, and the shipping entrance for trucks with its projecting loading and unloading rails.

Features That Mean Lower Product Cost

W. S. SEWELL

General Superintendent, The Strong-Scott Manufacturing Company
Minneapolis, Minn.

check room and tool room are combined, and one man, the toolmaker, is entirely responsible for both divisions. He makes sure that any tool drawn from the check room is in first class condition, and that no tool goes back into the check room without his inspection.

Elevator service, with its delays in waiting for cars and handling materials, has been minimized. Formerly production was held up frequently because parts had to be trucked between the machine shop on the first floor and the perforating section of the machine shop on the third floor, as well as between other departments.

Under present conditions the sheet metal shop is adjacent to the machine shop, whereas formerly there was not room in one building for both. Because office buildings had come to occupy the neighborhood of the main building of the old plant the sheet metal shop had to be located in another part of the town. The result was that many small jobs, which otherwise should have been done in the machine shop, were performed in the sheet metal shop in order to save the time of going from one place to the other, and vice versa. Now full cooperation is secured in the work of these two departments. Furthermore, a duplication of at least 20 per cent in the mild steel stock carried by the two shops was eliminated by centralizing the two stock rooms.

The monitor-type roof of the new building admits more sunlight. Monitor windows are controlled by handwheels placed conveniently below. There are 8,000 sq.ft. of window glass surrounding the first floor shops, which occupy a floor space of 27,000 sq.ft. The windows are of steel construction and fill completely the space between wall columns, as is shown in accompanying illustrations.

Our experience indicates that the monitor type of roof is superior to the saw-tooth design because of the difficulty in keeping the latter type from leaking. The monitor roof admits light without dark spots or shadows, and the cross-rays of light coming in through the monitor windows effectively serve the central portion of the shops, which is beyond the range of the windows in the side walls.

Improved lighting accounts for increased accuracy in manufacturing operations. In the old building, dies for the perforating machine were made under artificial light. Now they are made in natural light and, as a result, they line up better. The foreman of the machine shop believes that the difference in light eliminates at least 25 per cent of the trouble encountered in perforating dies.

Workmen are more contented because of the improved working conditions brought about by better lighting and ventilation. The result is that they produce more work and better work. Not a complaint has been received about the air or the temperature in the new building. The entire building is equipped with unit heaters, each of which is provided with thermostatic control so that the temperature varies no more than one degree F. Each section of the shop has its individual heat control because of varying requirements. On Saturday night the temperature of the entire plant goes down to 60 deg., but on Monday morning it is restored automatically to 72 deg. in the office, 65 deg. in the garage, and whatever temperature is desired in the shops.

End-grain, creosote-treated wood blocks are used on the surface of the shop floors because this type of flooring affords desirable working conditions. Noise of machines set on these blocks is deadened, and there is a noticeable lack of breakage of castings on account of the shock absorbing characteristics of this type of flooring. Accident hazards through slipping, falling, and exposure to splintering are eliminated. These features contrast pleasantly with those of the hard wood floor in the old building. A concrete floor covers all

parts of the basement stock room, with the exception of the center trucking aisle where wood blocks are used.

In the assembly of coal pulverizers the production cost has been cut 10 per cent because the new building is better adapted to this work than the old one, and the machines are arranged more efficiently. As the output increases it is believed that this saving will reach 20 per cent of the former production cost. Assembly operations were performed on the third floor of the old building, where the ceiling height was 6 in. under the height required to assemble the largest size pulverizer. In the new building the ceiling height is 14 feet.

Assembly is done in the central bay of the shop, which is 33 ft., 4 in. wide. The bays on each side of this area, also 33 ft., 4 in. in width, extend to the sides of the building. Here is located the machinery of manufacture.

In some cases portions of machines project into the assembly space, so that the 10-ton electric crane, which runs the entire length of the first-floor shops, can place heavy castings on the machine beds. This arrangement is used in the case of a large boring mill, the largest lathe, and a planer.

Whatever item is too heavy or bulky to be handled by the 6-ton electric elevator that operates between the first floor and the basement can be dropped into, or lifted out of, the basement by the crane through one of two 8x16-ft. trapdoors. One of these doors connects the sheet metal shop to the wood shop below, and the other one joins the machine shop with the storeroom underneath.

Another time and labor saver is the use of dumb-waiters for carrying small parts; one of them runs between each shop and the storeroom. A 5-ton, overhead monorail conveyor system for receiving goods passes over a dial scale in shipping room No. 1 for truck shipments, and another monorail is provided for outbound articles. Shipping room No. 2 for freight cars is on the opposite side of the building, and is connected to shipping room No. 1 by another monorail system.

A 30 per cent saving in storage space over that formerly required is obtained in the basement storeroom by using modern steel bins and racks. The adjustable features of this equipment make it possible to obtain the exact storage volume required without wasting space. Considerable space also was saved by placing a ceiling over the first floor washroom at a height of 7 ft., 6 in., which construction permitted the space above the ceiling to be used for a locker and lunch room, giving a double-deck effect.

Another monorail system runs the length of the basement storeroom. It is provided with branches at convenient points. This conveyor, one end of which goes over a scale, connects with another monorail in the wood shop. The garage is located at one end of the basement; it has a capacity for 20 cars and is provided with a wash rack.

To eliminate fire hazard a dust collecting system picks up small particles and sawdust coming from machines in the wood shop and carries them to a dust collector located in the coal bin. Because the collector is discharged into the coal bin the walls of the bin are washed down every two weeks to prevent dust accumulation, thus eliminating the hazard of an explosion.

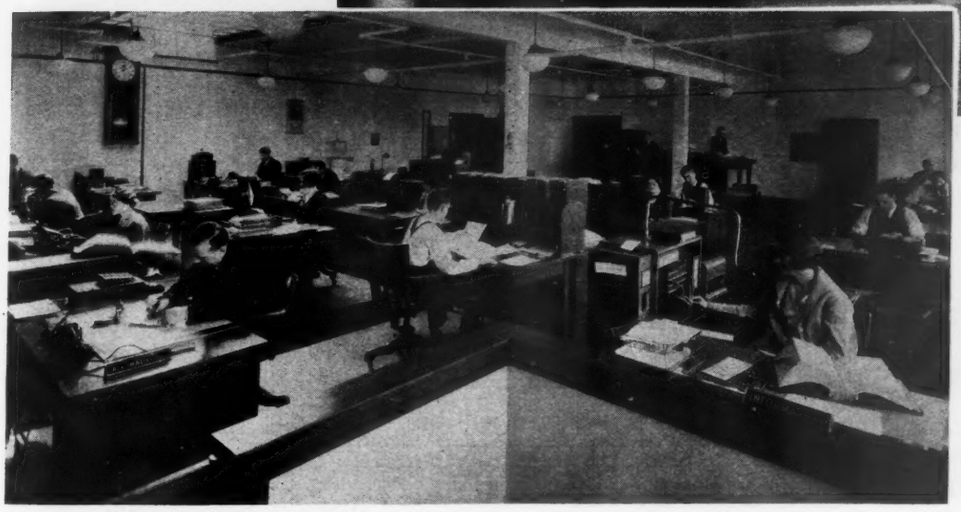
A vault in the general office protects the books; another vault is provided to safeguard drawings; and a third vault contains the flour mill bolting silk sold by the company. The general office has a skylight over the central portion and is provided with forced draft ventilation. Private offices are located at the north end of the building.

To give maximum light for men at the drawing boards the plan of the drafting room is L-shaped, with the drafting tables arranged around the sides of the room adjacent to the windows and the engineering offices located at interior points under skylights. This layout gives the draftsmen the greatest benefit of the light from the available window area.

Because one function of the company is to design new coal pulverizers an opportunity for experimentation is provided by trying out new or experimental units in the boiler room.

The main or assembly bay is kept clear of machinery to facilitate operations. The monitor windows admit all the sunlight required for efficient work. Floor of end-grain, creosoted wood blocks. Shipping rooms and offices at far end.

In this view of the main aisle of the basement storeroom can be seen the monorail track serving this area, the wood-block trucking aisle, the steel storage bins and, directly above, one of the trap doors through which heavy or bulky objects are moved from one floor to another.



General office. Forced draft ventilation and skylight provided. A temperature control system with separate units throughout the plant insures desired working conditions.

Pulverizers can be dropped through a trapdoor which connects the machine shop floor to the heating plant in the basement. The boiler used is rated at 150 hp. Sufficient room is available for the installation of another boiler should the building be enlarged. The coal bin will hold two carloads.

Electrically cooled drinking fountains are placed at convenient places in the shops and offices. Circular wash bowls of the spray or fountain type are used; they are large enough for a dozen men to use at the same time. There are two wash rooms, one in the basement and one on the first floor.

An automatic call system is used to signal the men in various parts of the plant. Bells were used at first for this purpose, but their sound was obscured by the noises in the sheet metal shop. The electric horn can be heard easily. The shop foreman's office is glazed on the sides so that he can observe the progress of the work around him.

Because no provision has been made for adding floors future expansion must be accomplished by extending the building. The building is now 100 ft. wide and 360 ft. long, whereas the length of the property on which it stands is 900 ft., allowing ample room for expansion.

We have concluded that the best place for a factory is in an essentially industrial district, away from congested retail and wholesale sections. In addition to psychological advantages that encourage work, this location provides other conveniences, such as ample parking space, plenty of room for delivery trucks, and adequate trackage.

■ ■

Financial Aids for Equipment Users

RECENTLY there has been some advocacy of the extension of the leasing of industrial equipment. Obviously the intent is to make unnecessary the diversion of operating capital. This proposal has been especially interesting because of the suggestions looking toward industrial plant rehabilitation made by the Robertson Committee. There has been no wide adoption of the leasing plan, but it may gain headway.

A somewhat similar plan has been announced by the newly formed Improved Industries Corporation, 521 Fifth Ave., New York City. It involves the lending of money, without notes, for the purchase of plant equipment on the basis of payment from reduced operating costs. The plan makes funds available only for the improvement of existing plants, not for expansion.

* * *

What has been done can be done. Read this month's factual article, "Lubricating the Path to Net Profit." Review, if necessary, the preceding articles of the same type dealing with electrical measuring instruments, lighting equipment, power factor corrective equipment. Watch for the coming articles in this series.

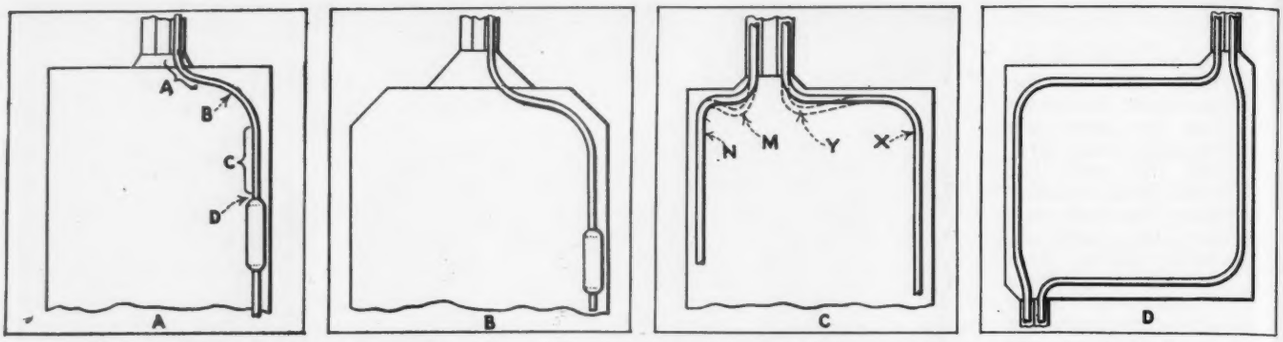


Fig. 1—With the design shown at *A*, cable bends at the duct are likely to be short and hence lead to early development of cracks. Longer radius bends are easier to make in the manhole at *B*. At *C* is shown the effect of short- and long-radius cable bends. *D* shows the shape of the manhole used by one large power company.

Cable Cracks and Cures

ROBERT W. DRAKE

Mechanical and Electrical Engineer, Chicago, Ill.

The plant that is regaining business and adding to its power load will be seriously handicapped if its underground cables are not in first-class condition. Cracks in the lead sheath cause as much or more trouble than anything else. This article tells what to do about them.

FIVE principal causes lead to failure in low-voltage (up to 2,300 volts) lead-covered, underground cable systems: (1) Over-heating of insulation due to overload or to hot spots resulting from local heating in the ground; (2) lead cracks; (3) electrolysis pitting; (4) duct mouth abrasion; (5) arcs caused by failure of an adjacent cable.

The first of these causes was considered in an article in the May, 1931, issue of *Maintenance Engineering*. This article will discuss the second cause, with some references to the fifth.

On low-voltage systems lead cracks cause at least as much trouble as insulation defects and overloading. When a lead crack allows water to enter a paper-insulated cable, the resulting failure should be charged to the crack and not to the insulation.

There are three general causes of lead cracking: (1) Flexure, or bending back and forth; (2) heating combined with flexure or with severe vibration; (3) impurities in the lead of the sheath.

Bending—In almost all cable systems there is some flexing of the cable in the manholes. The cable cools and contracts under light loads and expands when the load comes on. This causes motion at the mouth of the duct, the amount depending on the distance between manholes and on the temperature change.

In an industrial plant where most runs between manholes are not more than 400 ft., large cables ordinarily move $\frac{1}{4}$ to $1\frac{1}{2}$ in. in and out of the duct mouth, necessarily causing some bending of the cable in the manholes. Most cable sheath will endure slight bending daily for many years. As the severity of bending is increased at any one place the life before a crack appears is decreased much more than proportionally to the amount of flexure. With severe flexure cracks in the sheath may appear in a surprisingly short time, particularly if the cable runs hot.

In a manhole such as shown in Fig. 1*A* the bends at the duct mouth are likely to be short. Most severe bending is usually at *A*. Reverse bending is distributed over the bend *B* and over the cable along the side of the hole to *C*. Ordinarily, cracks appear first at *A*, but if natural bending is blocked by contact with the manhole wall, cable racks, or splices on other cables, the most severe flexure may occur where the cable enters the splice at *D*, and first cracks may occur there.

In manholes constructed as shown in Fig. 1*B*, much used in recent years, longer radius bends are easy to make. The slight extra cost will be repaid many times in increased cable life and decreased maintenance.

Wide manholes, allowing large offsets, decrease the flexure at the bends. It is evident that with the same run of cable and consequently the same motion at the duct mouth, the bends *X* and *Y* in Fig. 1*C* will be much less severely flexed than bends *M* and *N*. One of the largest utilities is using very large manholes because these may be said to be its only means of limiting lead troubles. Figure 1*D* shows the type of manhole used by another utility. In such a manhole cable pulling is somewhat less convenient.

Improper racking in the manholes may largely or entirely nullify the advantages of wide holes and large offsets. It is plain that if we strap a cable rigidly to the wall as shown in Fig. 2*A* bending at the duct mouth will be severe. Of course, such an extreme case is uncommon but a rack arm with deep grooves or flameproofing that strongly attaches the cable to the rack may have the same effect.

Various methods of racking avoid this difficulty. The old, homemade rack, Fig. 2*B*, is excellent if the pin is kept level. The paraffined block can slide freely on the rod. Usually there is an individual rack for each cable. It is never made more than two cables wide, because an extremely heavy stud would be necessary. Equivalent construction is available, however, for any width, as in Fig. 2*C*. There are a number of other racks on the market, on the principle of Fig. 2*D*, which allow motion. Much of the advantage of these racks which allow the cable lateral freedom is lost if one cable is allowed to limit the motion of another.

Next to the bends at the duct mouth the most frequent location of cracks is in the sheath immediately adjacent to the splice. Such cracks come from two causes. They can be recognized by the appearance of the sheath as shown in Figs.3*A* and 3*B*. Whenever a rod with a stiff portion, such as shown in Fig. 3*C*, is flexed there is a stress concentration at the change of section and it would be expected to crack first near *X*. In the case of a cable the splice is a stiff section. One common cause of such bending is a manhole arrangement such as in Fig. 3*D* or 3*E*. If the cable is large and stiff and the manhole is small the bending near the splice may be too severe for long life.

The cause of the crack shown in Fig. 3*B*, accompanied by a raised ring all around the cable at one or at both ends of the splice, is different. It was noticed years ago that many cable failures occur at the bends adjacent to the duct mouth. Some of these failures are caused by bending the cable so short, particularly in cold weather, that the paper is torn at the bend. The majority are caused by lead cracks.

An attempt to install cable practically without bends in the manholes did not succeed because the cable in the duct between holes still expanded when it became hot. Frequently the splice was the weakest point. The conductors inside bulged out as shown in Figs. 4*A*, 4*B* and 4*C*. At the splice the lead sleeve was stronger in compression than the cable sheath; so the cable core pushed forward into the splice. The cable sheath buckled and formed a ridge or a series of ridges all the way around and when the cable cooled off these ridges partly flattened out. Soon cracks formed near the wipe.

Occasionally some one racks cable straight through a hole, as in Fig. 5*A*. It is far better to widen the hole and to take the cables around, as Fig. 5*B* shows.

An installation of lead-covered cable racked in long, straight runs along a tunnel wall is often seen. If the supports are fairly close together so that the cable is held up straight, producing a "nice-looking job," the lead is likely to crack adjacent to the splices, as in Fig. 3*B*. If the sup-

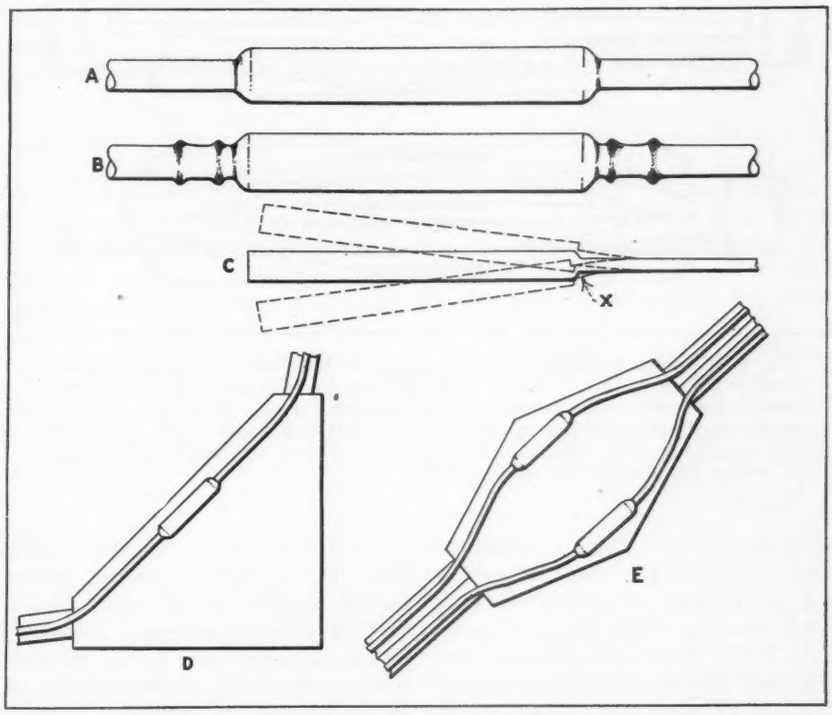


Fig. 3—The most frequent location of sheath cracks is immediately adjacent to the splice (*A* and *B*). Cable arrangements shown in *D* and *E* are common causes of the type of bending illustrated by the rod with a stiff portion, shown in *C*.

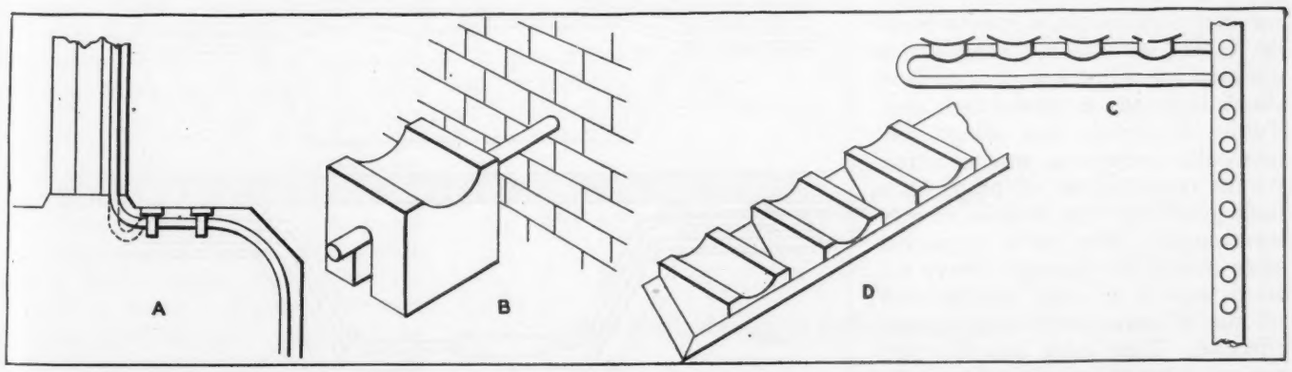


Fig. 2—Methods of racking cable in a manhole. Tight racking, *A*, causes severe bending. The old "homemade" rack, *B*, serves well if the pin is kept level. *C* is a rack built on the principle employed in the rack shown at *B*, for four cables. *D* shows a common type of rack permitting motion of the cable. When installing, joint compound and flameproofing cement must not be allowed to fall between the porcelains.

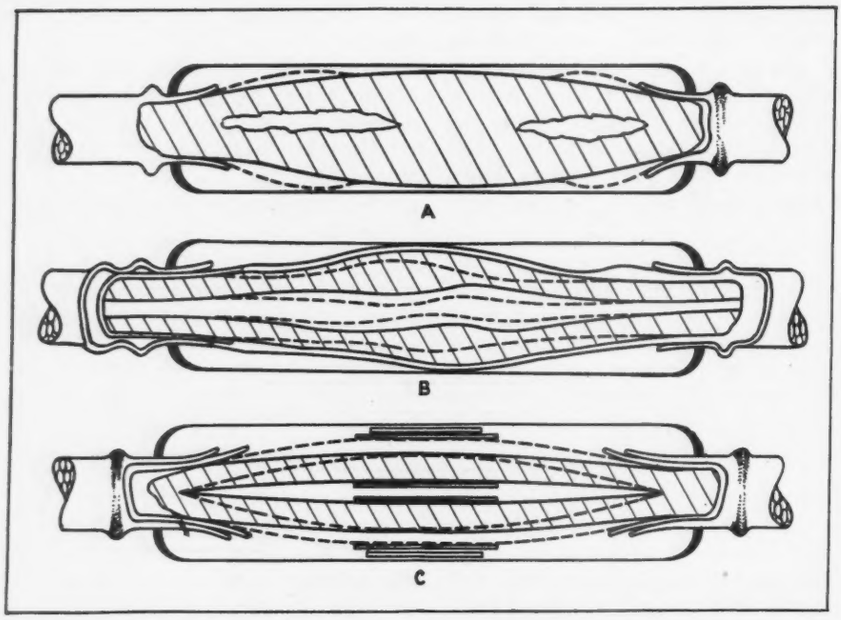


Fig. 4—Failures at splices when cables were installed in a manhole practically without bends. Hand-taped splice, *A*; thin belt insulation was considered sufficient because the voltage was low. *B* shows another hand-taped splice where space was left between conductors when the belt insulation was applied. The splice in *C* was insulated with tubes, in which the conductors fitted loosely.

ports are farther apart so that the cable sags between them, Fig. 6*A*, and particularly if care is taken to break down on it and sag it between racks before the splices are made, each span will take care of its own expansion and there will be no lead cracking at the splices. Another way of avoiding trouble is to build splicing vaults outside the tunnel, and lead the cable to the vault through slotted holes in the wall as in Fig. 6*B*. With steel-tape-armored cable in the tunnel and the splices in vaults outside, there is less likelihood of injury to the cable by men working in the tunnel.

Arc-Proofing — In modern, large systems an arc at a cable fault may in the second or less before a fault is cleared by relays do irreparable damage to a half dozen adjacent cables, and they in turn progressively cause the failure of others. Most plants use some sort of covering for the lead sheath to protect it against such arcs. Twenty-five years ago almost any reasonable protection was effective. As the concentration of power in a fault grew with the increase of system capacity there were occasional cases where, for example, heavy asbestos tape 3 in. wide, applied with silicate of soda, was not entirely effective. Then came asbestos felt, somewhat more effective but easily injured, and so on through a gradual development.

Probably the most popular covering today is cement mortar. Portland cement, Keene cement, quick-setting cement are all used. As a support a spiral of rope, a crossed double spiral of jute twine, asbestos mesh, a wrapping of cheese cloth, or expanded metal are used. Cement mortar coverings have excellent arc-resisting properties. However, they stiffen the cable, preventing uniform bending in the manhole. Bending is localized at a few places where the cement covering cracks, particularly at the mouth of the duct where expansion exposes uncovered sheath, less stiff than the coated cable. Under such conditions lead cracks develop at the points of localized bending much more quickly than with bare cable where the bending is distributed.

Arc protection of some sort is necessary. Except on the systems of the largest utilities asbestos listing with silicate of soda syrup almost invariably give satisfactory protection. If a minimum of silicate of soda is used, the cable is not stiffened greatly.

Where a cement covering seems necessary there are several expedients that will prolong the period before lead cracking begins. Large manholes with long-sweep bends and large offsets should be used. Cables should be covered with a wrapping of paraffined cheese cloth or, better, heavy, paraffined cotton tape, before coating with cement. The paraffined fabric coating serves two purposes. It reduces greatly chemical pitting of the lead sheath in wet holes, which sometimes occurs when cement containing free lime is used. Also, it breaks the bond between the cement covering and the minor irregularities of the sheath surface. This action decreases the stiffness of the cable and cement coating, on the principle that a pile of four 1-in. loose boards is not so stiff as a 4-in. plank of the same width. Experiments show that cable will stand about twice as many bending cycles with a heavy paraffined tape between the cement and sheath as without it.

Heating—On cables that run very hot, lead cracks are much more prevalent than on moderately loaded cables. It might seem that this is a result of the increased motion due to the greater temperature range, but that is not the whole story.

Lead sheath on very heavily loaded

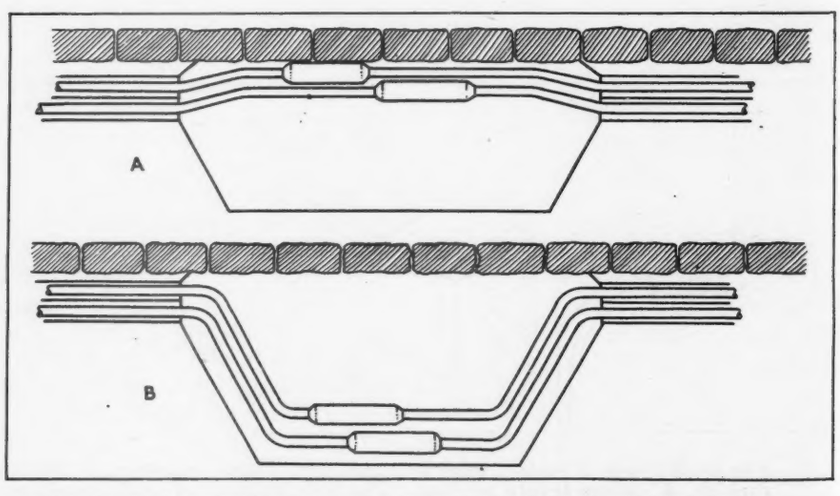


Fig. 5—Cables should not be racked, *A*, straight through a manhole. It is better to widen the hole as in *B*, and take the cable around.

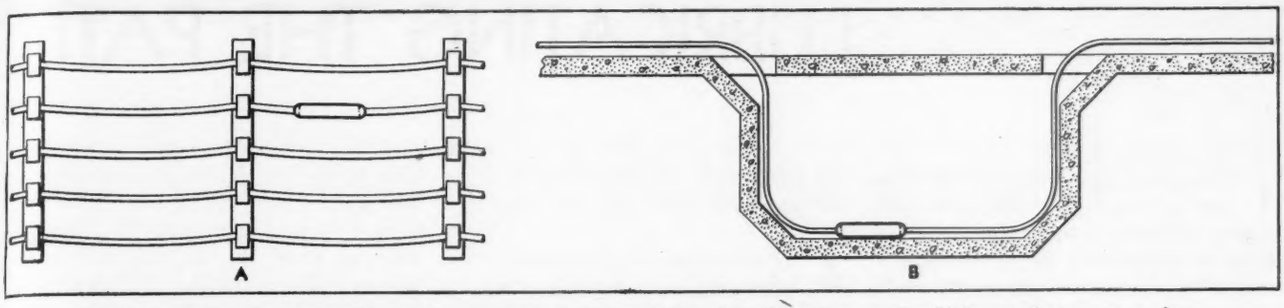


Fig. 6—When lead-covered cables are racked along a tunnel wall each span should be made to sag, as in *A*. A splicing vault, *B*, outside the tunnel will also help to take care of expansion.

cables develops cracks much more quickly than the sheath on cooler cables with equal severity of bending. In his treatise on cables Del Mar states that lead troubles, not insulation troubles, furnish the practical limitation in operating temperature for low-voltage, paper-insulated cables. My own experience confirms this. Even at sheath temperatures well below the temperature of boiling water the development of lead cracks is hastened greatly. Heat itself is insufficient to cause cracks, as proved by the fact that the cable back in the duct does not crack.

It is occasionally necessary to melt off a lead sleeve and wipe on another one. Sometimes this must be done more than once at the same splice. Too frequently to be merely accidental the sheath close to such a splice develops cracks within a year after a second or third sleeve is wiped on. In some cases it may be due to thinning of the cable sheath by too generous use of the shave hook. Where steel wool is used in place of a shave hook, this possibility is eliminated. Cracks frequently occur, nevertheless.

Defective Sheath—Manufacturers, led by one of the principal makers of aerial cable, are learning the cause of this difficulty. Very little such cable has been marketed in the past few years. Cable sheath showing this trouble will crack after bending or vibration without heating from load. For example, aerial telephone cable which swings with the wind, but does not heat up from load, exhibits this sort of trouble occasionally in an extreme degree.

Repairing — Patching lead cracks by soldering is futile. The sheath soon cracks again just outside the patch, or nearby. Figure 7 shows a better method, first published by Herman Halperin. A narrow band of lead in the vicinity of the crack is removed all the way around the cable. The gap is filled with varnished cloth tape to the level of the sheath; then a split sleeve made of cable sheath is applied and wiped at both ends.

Lead cracks adjacent to a splice are usually repaired by "blowing" the splice and wiping on a longer one. However, the cracks frequently recur. There is some evidence that every splice "blown" heat-treats the lead so as to promote further cracking. In every crack adjacent to a splice, if there is any evidence of the characteristic raised ring (see Fig. 3*B*) it is worth while not only to put on a new sleeve, but to make the splice over so that the conductors cannot spread and contract, as Fig. 4 shows.

Where tubes are used for insulation the space over the copper sleeves inside the phase tubes should be filled with varnished cloth tape, and the phase tubes should be a tight fit inside the belt tube. If no belt tape is used the phase tubes should be forced tightly together and bound securely with plenty of surgeons' gauze bandage stretched tightly, or with stay binding tape. Then the insulated conductors on each side of the tubes should be bound tightly together to prevent "hour-glassing" (see Fig. 4). If the splice is hand taped it should be examined for space inside between the conductors which might permit hour-glassing, and for ripped belt insulation, which may have resulted from hour-glassing under compression.

In general all this is worth doing, but occasionally it leads to worse trouble than it cures. If the splice is strengthened until the conductors no longer bulge under the stress and cracks just outside the wipe are thus avoided, it is occasionally found that the strains have been transferred to the duct mouth and produce lead cracks there, where repairs are more difficult.

Sometimes it is necessary to replace a length of cable because lead cracks continually recur at the duct mouth or elsewhere. When the old cable is pulled out we find the sheath of the portion that was in the duct is apparently in perfect condition. Should it be used elsewhere after cutting off the ends that were formerly exposed in the manholes? Yes, unless the insulation has been so overheated that it cannot stand rolling on a reel and unrolling again. (This discussion is confined to cable for 2,300 volts and lower.) It can be said that if the paper insulation cannot be crumbled up by the thumb in the palm of the hand, as a piece of leaf tobacco is crumbled before loading into a pipe, the cable will stand reinstallation. Of course, in the occasional cases where the trouble is due to impurities in the lead of the sheath ("bad sheath") the cables will crack again.

In some cases where a crack has been submerged and considerable water has entered the cable, it may be necessary to cut back some distance to get beyond the water; 20 ft. or 30 ft. is almost always enough.

(Concluded on page 459)

Fig. 7—A good way of patching a lead crack is to remove a narrow band of lead in the vicinity of the crack all around the cable, fill the gap level with the outside of the cable sheath with varnished cloth tape, and wipe on a split sleeve of cable sheath.

LUBRICATING THE PATH

1 Changing the brand of lubricating oil used in a Massachusetts cotton mill effected a saving in power costs estimated at $4,925 annually, which is somewhat more than the total cost of the lubricants used. A 7 per cent reduction in the annual power bill, from $70,458 to $65,533, followed a reduction in power requirements from 33.025 kw. to 31.50 kw. on four breaker and five finishing pickers, with a corresponding reduction from 14 kw. to 12.69 kw. in the spinning department.

2 With the roll-neck grease formerly used the average power required by a 16-in. cold rolling mill was 144 kw. After changing to a grease containing graphite the average power dropped to 108 kw., representing a saving of 36 kw. On the basis of 20 hours' operation a day, 24 days a month, the monthly saving in power amounts to $129.60. Deducting $4 a month for the increase in the cost of the grease, leaves a net saving of $125.60 monthly, or $1,507.20 annually on each mill.

3 In an Eastern textile mill much trouble was experienced with the bronze liners in the bearings of carding machines. Frequent replacement of liners was necessary and lubrication costs were high. A change was made to a lubricant that deposits on the bearing surfaces an extremely thin film of metallic zinc. Within a period of eight months no replacement of bearing liners was necessary and lubrication requirements had been cut from 1 gal. of oil daily to 1 oz. of the new lubricant every two days.

4 As the result of careful study of lubricants and methods of applying them to the plain-type babbitt bearings of a 34-in. rolling mill the power requirements were reduced from 150 kw. to 100 kw. It is estimated that the savings in power following the application of the same principles to all mills in the plant will pay for all lubricants used.

5 Bearings on three miles of lineshafting in one large plant were formerly lubricated by bottle oilers feeding ordinary red engine oil. Refilling was necessary every eight days and required the services of a head oiler and two assistants. A special oil that was developed expressly for lineshaft lubrication was substituted for the other oil. Subsequent experience showed that the feed could be reduced so much that refilling of the bottle oilers was required only every 64 days, thus eliminating seven out of every eight fillings. The savings in the cost of lubricant were large, and greater still in the cost of labor for oiling.

6 In a Northwestern flour mill that has an annual capacity of 400,000 bbl. plant records showed that power consumption was 3.89 kw.-hr. a barrel with the lubricants then in use. Extensive tests with other lubricants showed a power consumption of 3.79 kw.-hr. a barrel, representing a saving of 0.10 kw.-hr. There was a reduction in the friction load from 160 to 148 kw., which amounts to 12½ per cent. At a power cost of 1 cent a kilowatt-hour the annual saving in power costs is $400. Reduced consumption of oil and less labor required for oiling and cleaning increase this saving.

7 In a large Eastern cement mill lubrication costs had been gradually reduced to the low figure of less than ¼ cent a barrel of product. Then a thorough study of all lubrication problems gave rise to some changes in practice and the adoption of other lubricants. As a result lubrication costs have been reduced still further.

8 An Eastern plant that manufactures steel products and specialities was able to reduce bearing trouble on high-speed grinders and other equipment by 50 per cent through the use of a prepared graphite and oil mixture that is added in small amounts to the regular lubricating oil.

9 An example of how a reduction in the viscosity of oil will lead to power economy was recently observed in the lubrication of spinning frames in a textile mill. On these machines the use of an oil having a viscosity of 60 seconds Saybolt at 100 deg. F., in place of an oil having 100 seconds viscosity, showed a reduction in power requirements of approximately 4.8 watts a spindle. Such a saving mounts to a considerable reduction in power consumption in a large mill.

REDUCED to its essentials the function of the lubricant between two sliding surfaces is simple enough. Primarily, its purpose is to reduce friction and wear by preventing metal-to-metal contact through the formation and maintenance of a thin film of the lubricant between the opposing surfaces. Other functions which a lubricant may be expected to perform include sealing of bearings against the entrance of water and dirt; removal of foreign matter, including fine metal particles, from between bearing surfaces; removal of heat.

Performance of these functions in satisfactory degree is not always easy to obtain. On the one hand is the fact that bearings are made in a considerable variety of sizes, materials, and designs. They operate under a wide range of pressures, speeds, and temperatures. They may not always be of correct design or construction. Granted that they are correct in every particular when new, wear inevitably takes place, increases clearances, produces new conditions.

Many different kinds of devices based on various principles are employed to introduce lubricant into them.

Complicating the problem still further is the circumstance that lubricants are equally diverse in character. For present purposes they may be divided roughly into two classes: greases and oils. The former are some heavy vehicle, such as a calcium or sodium soap, mixed with mineral oil. In addition they may contain graphite

TO NET PROFIT

G. A. VAN BRUNT
Associate Editor

10 In an Eastern plant the average power required by a 60-in. mill rolling sheet zinc was 350 kw. After a change was made to a roll neck grease containing graphite it was found that the power required had dropped to 330 kw., representing a saving of 20 kw. With a power cost of $0.0125 a kilowatt-hour the saving in power costs over a 10-hr. day, 24-day month is $48, after deducting the increased cost of the grease, or a net saving of $576 a year.

11 A Middle-Western rubber reclaiming plant with an annual output of 14,000,000 lb. reduced the cost of repairs and maintenance from $3.007 to $1.297 per 1,000 lb. of rubber by a change to other lubricants. This reduction in maintenance costs amounts to nearly $24,000 a year.

12 A manufacturer of textile mill equipment had experienced much difficulty in obtaining proper lubrication of certain parts of an important machine. With the methods formerly used it was necessary to oil one of the elements, a chain, at least once a week and unless much care were taken the oil was likely to be thrown out and spot the material. Adoption of a heavy-bodied lubricant that produces a very thin coating of metallic zinc on the bearing surfaces eliminated the troubles formerly encountered and made it possible to reduce the frequency of lubrication to once every three or four weeks, with no danger of injuring the product.

13 At an Eastern paper products plant excessive amounts of carbon in the air compressors necessitated cleaning the valves once every two weeks. Investigation disclosed that the wrong grade of oil was being used and fed at the rate of 96 drops a minute. After another lubricant was substituted the rate of feed was immediately reduced to 20 and eventually to 4 drops a minute. Any reduction in the rate of feed with the oil previously used had caused the pistons to groan and squeal.

The compressors have now been operated for more than six months without drawing the valves, whereas previously they were cleaned every two weeks at a cost of $5 a valve. There are four valves in each compressor; hence, the saving is $40 a month or at the rate of $480 a year on each one. Although the new oil costs about twice as much as the other there is a considerable net saving in the annual cost, since consumption has been reduced greatly.

14 In the shop of a Middle-Western monument company a 10-hp. motor drives an air compressor and a polishing machine. Addition of a prepared graphite and oil mixture to the lubricating oil used in the motor, compressor, and lineshaft bearings reduced the power consumption by 100 kw.-hr. a month. The net saving is between $40 and $50 annually.

15 Lubrication costs were reduced $2,244 a year in a Pennsylvania mill that makes boxboard by proper selection of the lubricants and improved methods of applying them to various machines.

16 Studies of lubrication requirements and practices in a Middle-Western rubber plant have resulted in reducing lubrication costs, including material and labor, from an original index cost of 150 for each 1,000 lb. of product to the present index of about 47. Annual production approaches 200,000,000 lb.; savings are estimated at nearly $200,000.

17 Much trouble was experienced in an Eastern plant with the bearings in polishing jacks, whose shafts are driven at 3,360 r.p.m., and were lubricated with a light grade of engine oil. One or more bearings burned out each week. The temperature of the bearings was about 148 deg. F., on the average.

In the belief that the oil used was too light a heavier grade was tried in one of the bearings, contrary to recommendations. Within a short time the temperature rose to 156 deg. F. and the machine was stopped in order to avoid an inevitable bearing failure.

Upon substituting light-bodied oil of more film strength for the other oil the temperature dropped to about 120 deg. F. and there have been no bearing failures during the past two years. The lighter grade of oil now used costs somewhat more but there is a saving of approximately $4.85 a week, say $250 a year, in the cost of replacing bearings.

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or some other solid material, added to improve the lubricating qualities or increase the "body."

Lubricating oils used in industry are mostly derived from natural crude oils, although certain animal and vegetable oils find a limited use alone or, more frequently, mixed with mineral oil. Crude oils vary widely in composition and characteristics; the refined oils derived from them vary still more widely in their properties.

The result is a bewildering assortment of oils, with greases thrown in for good measure, from which the maintenance engineer is required to choose those that best meet his requirements. How to match up lubricants and bearings in order to make the best working combination under the conditions of service is a problem of major importance. Mistakes are easy to make. The results may be disastrous and take the form of burned-out bearings; scored journals; increased maintenance costs; heavy losses through delays to production. If the results of errors fall short of these extremes there is likely at best to be unnecessarily heavy losses in power due to friction between the bearing surfaces or within the lubricant itself; trouble from overheating; increased wear.

That many mistakes are made in the selection of lubricants is inevitable and obvious. It will be equally obvious from the examples cited that thorough study of lubrication problems may result in important savings.

The low lagging power factor of a synchronous motor that is operating out of step will cause this relay to function and remove field excitation, so that the motor can exert maximum torque and re-synchronize when conditions become normal.

S. C. EWING

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General Electric Company
Schenectady, N. Y.

These Methods Increase Synchronous Motor Protection

PROTECTION for the motor at all times is most important in the application of control equipment for synchronous motors, in order to obtain the maximum service with minimum maintenance. It is the function of control equipment to provide this protection as well as to make the proper connections for the starting and running conditions. Hence it may be said that:

1. Control equipment must provide suitable means for applying a.c. power to the motor.
2. Means should be provided for applying field excitation automatically when the motor has reached the proper speed.
3. Field excitation removal should be automatic if the motor falls out of step.
4. The motor should be resynchronized automatically when conditions permit.
5. The squirrel - cage winding should be fully protected from overheating caused by abnormal operation out of synchronism.
6. The stator winding should be fully protected from overheating caused by all operating overloads.
7. Instantaneous or time delay undervoltage protection or undervoltage release should be provided.
8. Indicating or recording instruments should be included to guide the user in operating the motor.

Power Application — Synchronous motor controllers may be classified according to the method of applying power during the starting period as:

(*a*) Semi-magnetic, reduced-voltage controllers of the auto-transformer type.

(*b*) Semi-magnetic, reduced-voltage controllers of the resistance type.

(*c*) Magnetic, full-voltage controllers.

(*d*) Magnetic, reduced - voltage controllers of the auto-transformer type.

(*e*) Magnetic, reduced - voltage controllers of the resistance type.

(*f*) Magnetic, part-winding, reduced-kva. controllers.

(*g*) Magnetic, reduced - voltage controllers of the reactor type.

Semi-magnetic controllers provide automatic control of the connections to the synchronous motor field; the a.c. power connections are made by means of manually operated contactors or breakers.

Magnetic controllers provide automatic control of all connections to the motor. With this type of control the pilot circuit is closed by means of a pushbutton or other device; the remainder of the starting operation is entirely automatic.

A full-voltage controller connects the motor directly to the power source at start. A reduced-voltage (auto-transformer) controller connects the motor to a suitable reduced-voltage tap of an auto-transformer at start. Upon reaching maximum speed the motor is connected directly to the power source or normal line voltage.

Reduced-voltage (resistor) or "increment-type" controllers provide reduced voltage at start by inserting a resistor in series with the motor windings. This resistor is shorted out in successive steps until full or normal line voltage is applied.

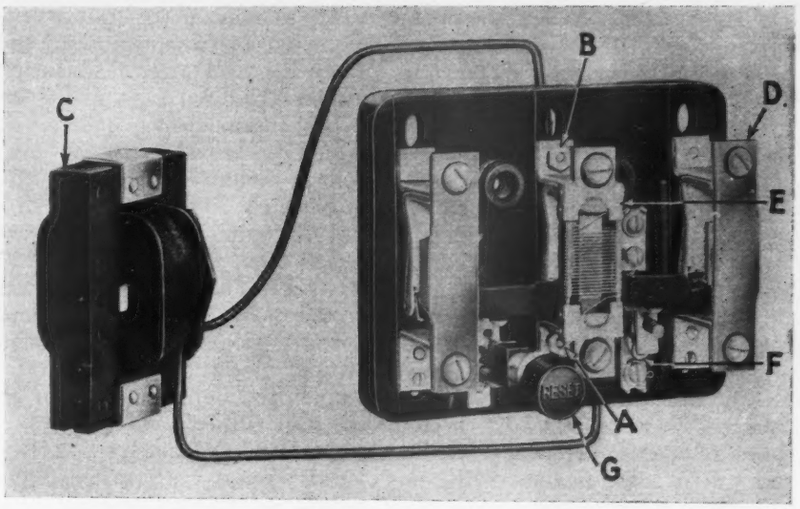
The part-winding controller provides the effect of reduced-voltage starting without the use of an auto-transformer, resistor, or similar device. A multiple-circuit winding is used in the motor. When starting, one or more of these circuits, comprising only part of the winding, are connected to the power source; hence, the motor starts with reduced current and torque. After it has accelerated to the maximum speed attainable with part of the winding in the circuit, the remainder is energized, allowing the motor to operate normally.

Field Application — In applying synchronous motors to loads where conditions such as voltage, friction, acceleration time, etc., vary widely, it has been found to be very important that excitation be applied at the proper motor speed for the maximum pull-in torque and minimum line disturbance.

One of the latest devices developed to accomplish this operation is a "Slip - Frequency, Field - Application Relay," which operates as a function of the slip frequency, or slip speed.

This device is connected across a section of discharge resistance in series with a half-wave copper oxide rectifier. During the starting period the induced field current of slip frequency flowing through the discharge resistor causes half-waves of slip-frequency current to pass through the relay coil, making the relay pick up and open its normally closed contacts. The relay is provided with a copper jacket which gives it a short time delay and prevents dropping out between the half-waves of coil current. As the motor speed approaches synchronism the time interval between the half-waves of current become long enough for the relay to drop out and apply field to the motor.

Time setting of the relay for drop-out can be varied to apply field excitation at any speed from 92 to 99 per cent of synchronous speed. Operation is independent of the magnitude of induced field current or line voltage. The relay depends only on the time interval of a slip cycle, determined solely by the motor speed.



Protection for the squirrel-cage winding is provided by a single-element temperature relay which is put in the field discharge circuit in parallel with a reactor. Division of current between the relay and the reactor depends on the slip frequency; hence, it is a function of the motor speed. "A" and "B" are the heater element studs. "C," reactor, which is mounted at the rear of the controller. "D," temperature overload relay element. "E," temperature squirrel-cage protective relay element. "F," control contact, overload relay and squirrel-cage protective relay. "G," reset button.

Field Removal—If excitation is not removed in the event of operation out of synchronism because of voltage disturbance or mechanical overload the motor may stall, resulting in high current inrush and excessive heating.

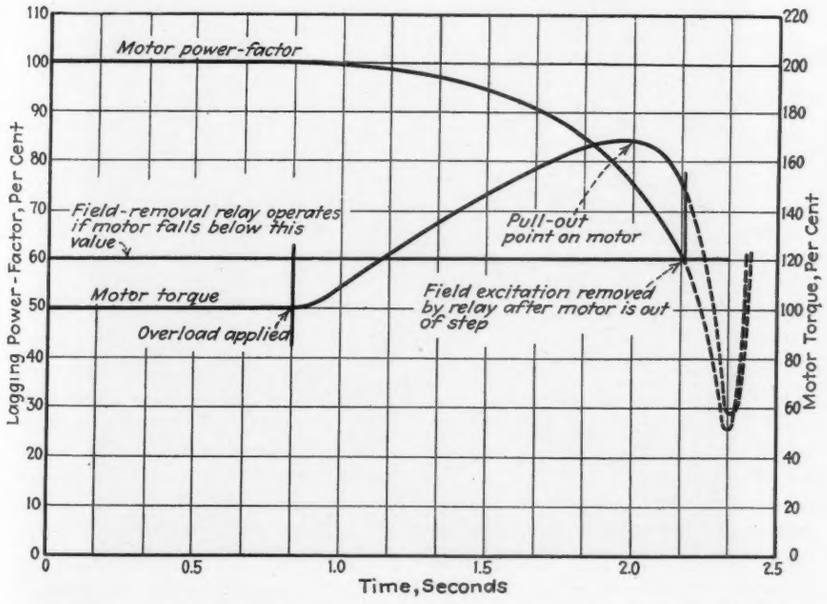
A relay for automatically removing the field when the motor pulls out of synchronism has recently been developed for use on magnetic and semi-magnetic controllers. Known as the "Power-Factor Field-Removal Relay" it depends for operation on the power factor of the current drawn by the motor.

If the motor falls out of step the resulting low lagging power factor (under 70 per cent) will cause the relay automatically to remove field excitation by opening the field contactor and simultaneously closing the discharge contactor, thereby allowing the motor to exert maximum pull-in torque and re-synchronize when conditions permit. The result is a minimum number of complete shutdowns, less lost time, and reduced heating.

When a magnetic form of unloader is used, as on an air or ammonia compressor, or where the motor has sufficient torque to synchronize under load, use of automatic field removal equipment allows the motor to operate without interruption under momentary voltage dips or overloads.

Squirrel Cage Protection—During recent years study has been made of the problem of adequately protecting the squirrel cage of a synchronous motor. It is generally understood that the squirrel-cage winding is only a starting winding and that for economical and efficient design of synchronous motors the volume of conducting material in the squirrel cage should be much less than in the stator winding. The thermal capacity of the squirrel-cage winding, therefore, is lower than that of the stator winding. Any excessive addition of copper to the squirrel cage acts to increase the air gap, cause saturation of field flux, increase physical dimensions and quantity of material, and decrease over-all operating efficiency.

One type of device that fully protects the squirrel cage consists of a temperature relay which simulates the heating characteristics of the squirrel cage and operates to disconnect the motor from the line before this winding overheats. It is known as the "Temperature Squirrel-Cage Protective Relay," and is a single-element temperature relay, connected in the field discharge circuit in parallel with



How the power factor of a typical synchronous motor varies as it pulls out of step on overload.

a small reactor. When the motor operates out of synchronism induced field current flows through the relay heater and reactor. The division of current between the relay and reactor depends upon the slip frequency and, therefore, on the motor speed. Near synchronous speed the slip frequency and the impedance are high, so that most of the current passes through the heater element. Thus the tripping time of the relay is a function of the motor speed. By properly proportioning the reactor coil and the heating element a relay is obtained that follows the heating curve of the squirrel-cage winding and will trip the motor off the line before this winding overheats, regardless of whether the motor is stalled or operating at any sub-synchronous speed.

Stator Overload Protection—In a motor stator heat is generated in the copper, conducted through the insulation into the iron, and then carried by convection and radiation into the air. The copper is always the hottest and the iron acts as a cooler, the difference in temperature between the iron and copper determining the rate of cooling. On this principle as a function of the stator current it is possible to simulate the heating characteristics of synchronous motor stators by a temperature overload relay in the stator circuit which protects the motor against all operating overloads by disconnecing it. To prevent restarting before an investigation is made as to the cause of abnormal operation, the relay control contacts are provided with a hand-reset device.

Undervoltage Protection — Undervoltage protection may be divided into three general classes:

(*a*) Time-delay undervoltage protection provides for continuous operation during a momentary power disturbance by a time-delay pushbutton; by mechanically latched-in, time-delay opening switches; by d.c. operated switches actuated by storage batteries or other reliable source; or by inductive time lag devices.

The time-delay action of the undervoltage device is usually set for 1 to 2 seconds; then if power is not restored the equipment is automatically disconnected from the line and manual estarting is required.

This type of protection is recommended for continuity of service and to enable the motor to resynchronize automatically as soon as power is restored, providing it has suitable starting and pull-in torques for the load, or magnetic unloading means are provided to remove the load when the motor is out of synchronism and to apply the load after field excitation has been restored.

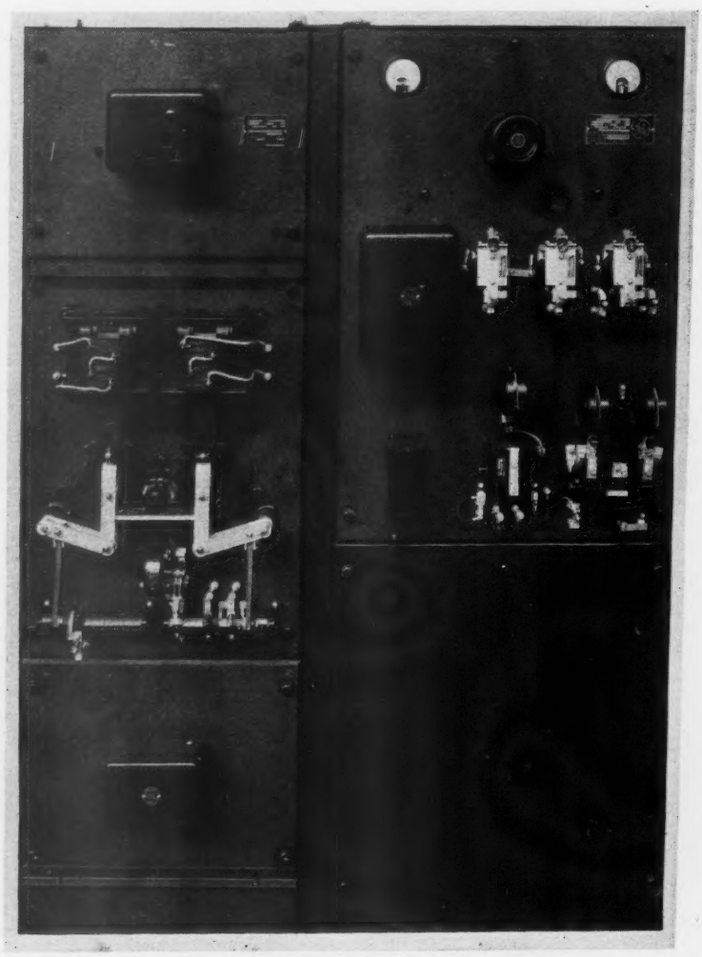
(*b*) Instantaneous under-voltage protection provides that in case of voltage failure or reduction to approximately 50 to 60 per cent of normal the equipment will be disconnected from the line and manual restarting will be required. It is usually provided by means of a manually operated momentary-type pushbutton station, which holds the circuit to the motor open until the operator closes the start button.

(*c*) Undervoltage release is provided when a float switch, pressure switch, or any maintaining type of actuating device is used to control motor operation. After a motor has stopped or pulled out of synchronism because of voltage disturbance it automatically accelerates and synchronizes upon the return of power. With this type of protection the motor must have sufficient starting and pull-in torque to accelerate and synchronize the load, or means must be provided to load and unload the driven machine automatically.

Indicating Instruments—To enable the operator to observe the performance of the motor under various load conditions and to maintain the proper power factor for maximum efficiency, it is desirable that ammeters reading line and field excitation current be a standard part of the controllers.

Other devices such as power factor and watt-hour meters, wattmeter, or voltmeters may be added as required. Where the controller is remote from the operator, indicating lamps, horns, or bells are sometimes employed to signal operating cycles.

If a synchronous motor is not fully protected against stalling or abnormal acceleration time, application of excitation at the wrong motor speed, failure to remove field excitation on pull-out from synchronism, failure to provide means to re-accelerate and re-synchronize under certain conditions, undervoltage protection, and protection from abnormal overload operation, its operation is impaired greatly.



Magnetic, reduced-voltage, synchronous motor controller that provides automatic field application and removal, with stator and squirrel-cage winding protection.

MAINTENANCE ORDER SYSTEMS

Part X—Large Plant, Simple Maintenance Routine

G. I. ROSS

Chief Engineer, MacDonald Bros., Inc., Boston, Mass.

AN ORGANIZATION of the size described here, a plant employing 20,000 people, could, of course, make use of any one of a large variety of order systems. Under the system devised, simplicity is retained, yet a rigid check on labor expended is provided.

All maintenance work is performed only on the authority of written orders. These orders are handled in a systematic manner through a job control routine.

This system provides at all times a record of:

(*a*) Jobs
1. On hand
2. Under way
3. Started but held up
4. Completed

(*b*) Employees
1. Location of work
2. When beginning work
3. Job to which assigned
4. When finished.

(*c*) Labor requirements for each job.

The maintenance order authorizing the start of a job does not differ greatly from that found in the smaller plants previously described, but the *individual work orders* present a new angle of control.

Individual Work Orders—Work orders are issued for every employee in the Maintenance Department (except those on supervision). The form used for the maintenance work order is shown in the accompanying illustration.

The work orders are filed on a control board, thus providing a visible record of the jobs in process.

The "finished" work orders for each day are sent directly to the Cost Department to be used for distribution to the proper accounts.

Job Control System—In this plant the Maintenance Departments are widely scattered, and so it is not practical to have one central Job Control Office. In order to have the time taken by the workmen between jobs reduced to a minimum, there are a main control office and branch offices. A job control clerk is in charge of each control office. There is sufficient contact between offices to permit shifting of workers in order to keep the forces at a minimum.

The foremen of the various maintenance departments are required to cooperate with the job control clerks in order that the least amount of workers' unassigned time be charged to the Maintenance Department.

Our series of "case studies" of maintenance order systems would not be complete without considering at least one major plant.

In this article, the last of a series of ten, Mr. Ross discusses the order system used by a plant of 20,000 employees, manufacturing metal parts and assemblies.

Duties of Job Control Clerks—The job control clerks handle the following tasks:

(*a*) To see that every man in the Maintenance Department (except those on supervision) is provided with a work order at all times

(*b*) To make out the work order in duplicate

(*c*) To stamp the order on the recording time clock to show the elapsed time

(*d*) To keep a complete list of all the jobs that have regular men assigned each day. (This list includes elevator operators, crane operators, oilers, repair men, power-house men, and the like, and shows the clock numbers of the men, both day and night, that are assigned to these jobs.) The clerks must check daily with the various foremen to see that this list is correct

(*e*) To keep a complete list of all the maintenance expense accounts

(*f*) To keep a list showing the location of the office of every department, arranged according to floor, building, and bay

(*g*) To decide, when a request is received for work to be done, whether it is general maintenance or new construction work. (If it is new construction work, an order must be issued by the Plant Engineer; if there is any doubt whether the work is general maintenance or new construction, the work order is referred to the Superintendent of Maintenance)

(*h*) To designate the cost number

to which the work is to be charged. (This is obtained from a list of "Maintenance Expense Accounts" on hand)

(*i*) To mark in the spaces marked "Department," "Floor," "Building," and "Bay" on the work order the proper entries, so that the workman will not lose time in locating the place where the work is to be done

(*j*) To mark the workman's clock number in the space captioned "Workman's No.," before the work order is given him

(*k*) To check, in the spaces provided on the work order, if the job is finished or not finished, when a work order is returned by a workman; to secure additional data from the workman on the work done, and to place this information under "Description."

The day clerk is responsible for having the first assignment of work ready for the night workmen, and the night clerk is responsible for having the first assignment of work ready for the day workmen.

Classification of Work Orders—There are four classifications of work orders, as follows:

Class "A"—New construction work

Class "B"—General maintenance work

Class "C"—Regular duties performed in certain departments

Class "D"—Unassigned time chargeable to the Maintenance Department.

Class "A" work orders (new construction work) are made out by having the foreman (in charge of each maintenance department) specify the number of men required, giving their clock numbers and information as to the nature of the work to be done. This information is given to the job control clerk before the men report for their next assignment of work.

Class "B" work orders (general maintenance work) are for trouble calls received direct from a foreman. These are mostly RUSH orders and receive prompt attention. The RUSH orders are given to the first man that reports who is qualified to do the work. In some cases it is necessary to get in touch with a man and to transfer him from the work he is doing to the RUSH work without having him report back to the job control office. This is taken care of without confusing the records of the man's time.

Class "C" work orders (regular duties performed in certain departments) are made out from the list previously referred to. One of the purposes of the job control system is to have as few men as possible working on class "C" work orders.

Class "D" work orders are issued to men for whom it is not possible to issue either class "A," "B," or "C" work orders. These men are assigned to jobs in their respective shops. The foreman is required to give the job control clerk an exact description of the work performed.

Routine—There is a file for *new construction orders* arranged by maintenance departments. This file is divided into the following sections:

(*a*) Work in Process

(*b*) Work Ahead

1. Started but held up (red tab if waiting for material)
2. Not started
   (*a*) Available
   (*b*) Waiting for material

(*c*) Work Completed.

There is also a file of work orders for *general maintenance work* arranged by maintenance departments. This file is made up with the work orders for each department divided into three sections as follows:

(*a*) RUSH Orders

(*b*) Available Orders

(*c*) Finished Orders.

Referring to the file of new construction orders, cards are made out for each department that will do work on the order. (For example, the work may require carpenters, electricians, and millwrights, so that three cards must be made out.) The Superintendent of Maintenance furnishes the date on which the work is to be started by each department. As soon as workers are assigned to work on a new construction order, the card is placed in the "Work in Process" section. All other new construction order cards are in the "Work Ahead" section, which is divided into (1) work started but held up, and (2) work not started. The latter classification includes work which is available, with RUSH orders placed at the front. This section also includes new construction orders which are not available because of delay in obtaining material.

In regard to the general maintenance file previously mentioned, when the request is received for work to be done, the work orders are made out (the time and date stamped on the reverse side of the original copy) and both original and duplicate copies placed in either the general maintenance file or on the control board. The work order is not placed on the control board unless it can be assigned to the individual workman. All other work orders are placed in the general maintenance file with the RUSH orders at the front of the section for each department.

Should a new work order be made out for the workman who is working on a job, a new order (both original and duplicate copies) is placed on the control board behind the work order being worked on.

The original of the work order is left on the control board, after being stamped with the time clock, and the duplicate is handed to the workman.

When a workman reports for a new assignment of work, the original copy of the new order and the original copy of the last order are properly stamped (on the reverse side). The time is then inserted in the "Elapsed Time" space on both copies of the last work order, and both copies filed in the

MAN NO.	ACCOUNT NO.	ELAPSED TIME
DEPT.	FLOOR / BLDG. / BAY	
REQUESTED BY	JOB FINISHED CHECK ☐	JOB NOT FINISHED CHECK ☐
DESCRIPTION		

MAINTENANCE WORK ORDER

Fig. 20—Maintenance Work Order. Original blue, duplicate salmon. Work orders are issued for every employee in the Maintenance Department, except those on supervision. Actual size, 5x3 inches.

"Finished" section for the maintenance department that did the work.

When the workman has finished his shift, he returns his last work order to the job control clerk. If the job is unfinished, a new order is issued.

In figuring the elapsed time, allowances are made for lunch periods.

All "finished" work orders for each shift are filed daily by consecutive clock numbers. Work orders for individual workmen are arranged in the order in which the work was performed. The work orders are checked to see that all the men have all of their time accounted for.

The original copies are sent directly to the Cost Department to be used for distribution to the proper accounts. The duplicate copies are filed, by dates, in the Maintenance Office.

If should be reiterated that this article and others of this series were not intended as a treatise on form design. The forms were introduced merely to show how they are made an integral part of the maintenance routines described. If the cases cited provide helpful suggestions to those who lack a maintenance routine or have a cumbersome one, it will be simple to devise suitable forms.

Cable Cracks and Cures

(Continued from page 451)

Six feet should be cut off at a time and insulation resistance measured.

Cable for a.c. service at 440 volts and below will stand up with so much moisture that a 300-ft. length of three-conductor, 500,000-circ.mil cable has only 100,000 ohms insulation resistance from the worst phase to the other two phases and sheath: say, one-thousandth to one fifty-thousandth of the value that good cable usually shows. It is, of course, well to cut off somewhat more and improve so low a reading. There is a serious disadvantage in scattering occasional lengths of such cable in longer runs of drier cable. Insulation resistance tests in the future would be of little use in detecting the entrance of water through lead cracks or electrolysis pits. It is better to install such cable in runs by itself, if possible. Successive insulation resistance measurements on such cable generally show improvement as the moisture becomes distributed particularly if the cable is heavily loaded.

For 2,300 volts and higher, I never have had the courage to reinstall any cable that was so wet as this. Theoretically, for the same local heating from leakage current at 2,300 volts a 300-ft. length having 2½ megohms insulation resistance from one phase to the other two and the sheath should stand up.

In an intelligently planned cable system where it takes a man two weeks to make the semi-annual manhole inspection with mirror and flashlight four or five sheath defects, perhaps only one, are as many as will be found at most. Such a job requires a patient inspector who will be just as painstaking as ever in the seventy-first hole, after finding nothing in the preceding seventy.

It is well to emphasize the fact that lead cracks may be expected to recur after repair or replacement of cable unless some change is made to spread the bending over more cable. The cause remains and may be expected to produce the same result again, soon in the case of old cable that has been repeatedly flexed by expansion, and after a longer period in the case of new cable that has replaced old.

REDUCING THE COST OF MAINTENANCE

Tool Room Window Waiting

GEO. P. PEARCE

REPAIR orders received by the millwright department practically never contained any information of value to the millwright foreman. The departmental foreman would just scribble: "Repair 841 molding machine, or "Adjust 600 press," or something equally vague. The result was that the millwright foreman sent a millwright to find out what was needed and the millwright generally took his helper along.

On the return trip the helper would go to the tool room to gather what parts they thought would be needed while the millwright talked the job over with his foreman. After all this the repair job was actually started and was always followed by anywhere from two to a dozen trips by the helper to the tool room for other things missed on the first trip.

This system was expensive no matter how you looked at it. The tool room window was always crowded. Men waited in line and swapped yarns while the toolroom clerk rushed about making up odd orders.

The master mechanic cured this evil by having each millwright make out a list of tools and supplies he found he generally needed on ordinary repair jobs. The millwright foreman and the master mechanic then made out a master list.

It was turned over to a draftsman who designed a steel tool chest with a convenient pocket or tray for everything on the list. The chest was equipped with large castors and handles so it could be pushed around the plant.

About this time the toolroom clerk, an old Scotchman, heard what was going on and suggested that the top of the chest be made of 1¼-in. oak with a 4-in. vise bolted to it. This vise eventually became one of the handiest gadgets in the plant. Five of the chests were built, equipped, padlocked, and the keys given to the millwright foreman.

After that, when a millwright was sent on a job, he was given the key to one of the chests and he and his helper usually were able to finish the job and get the departmental foreman's release in a single trip.

When the millwright finished a repair job he would order what was needed to restock the tool chest. The millwright foreman would then check the various compartments to see that nothing was missing—and since every compartment had to be full this check took but a minute—he locked the box, kept the key, and the chest was ready for the next job.

MAINTENANCE ENGINEERING

L. C. MORROW, Editor

DECEMBER 1932

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Bespeaking Cooperation for the Rehabilitation Committee at Work

EFFORTS of the Robertson Committee on Industrial Plant Rehabilitation are bearing wholesome fruit. Individual commitments are being reviewed in the daily press; they have become public knowledge, hence no complete list is necessary here.

Among the big ones are those of the Creighton plant of the Pittsburgh Plate Glass Company for $350,000 made available for plant improvements and deferred maintenance; of the Standard Oil Company of New Jersey for $20,000,000 for maintenance and improvement of its American plants between September 1, 1932, and June 30, 1933; and a collective $70,000,000 announced by the chairman of the national committee.

Men responsible for engineered maintenance are in accord with the objectives of the committee, as they should be. They have had the experience of living within snipped budgets while they watched plant and equipment become less able to fulfill functions efficiently.

Leaders among these men have expressed themselves as in sympathy with the policies of *Maintenance Engineering*, favoring modernization of the operating parts of plant and equipment looking toward lowest cost per unit of product, to maintain strongest competitive ability, and therefore secure greatest net profit.

Help from the men in the plant is necessary if the men in the front office are to give the rehabilitation suggestions of the Robertson Committee full measure of consideration.

Maintenance Engineering has for two and a half years urged detailed examination of plant and equipment, and has recommended the recording of the facts found. With its March issue of this year it made available an Industrial Plant Survey Check Sheet on which the facts could be set down. Since then the editors have several times urged the full use of the check sheet. It now becomes apparent that an assembly of the facts for which entry space was provided on the check sheet can be of the utmost importance in the present active rehabilitation movement. We bespeak the co-operation of the men in charge of the maintenance function.

■

Daniel H. Braymer

A CAREER of exceptional activity and accomplishment in the fields of engineering and publishing came to an untimely end with the death of Daniel H. Braymer at Omaha, Neb., on October 29.

Born in New York State in 1884 Mr. Braymer won degrees in science and electrical engineering at Cornell University. Following his graduation he was associated for several years with the Westinghouse Electric & Manufacturing Company, the Electrical Testing Laboratories, and the Western Electric Company. His unusual talents found a welcome outlet in the preparation of technical articles which appeared in numerous engineering publications, and led to his appointment as associate editor of *Southern Electrician*. In 1915 he joined the McGraw-Hill Publishing Company as engineering editor of *Electrical World*, later becoming managing editor and co-editor.

When the *Electrical Review* was purchased in 1921 by the McGraw-Hill Publishing Company, Mr. Braymer was placed in charge of the publishing and editorial policies of the magazine, which then became known as *Industrial Engineer* and later adopted the present name of *Maintenance Engineering*. His work in molding this publication is well known to many readers.

In 1925 Mr. Braymer gave up his publishing activities to organize in Omaha, Neb., the D. H. Braymer Equipment Company, which specializes in consulting and sales work in the field of power applications in industrial plants, power plants, and large buildings.

■

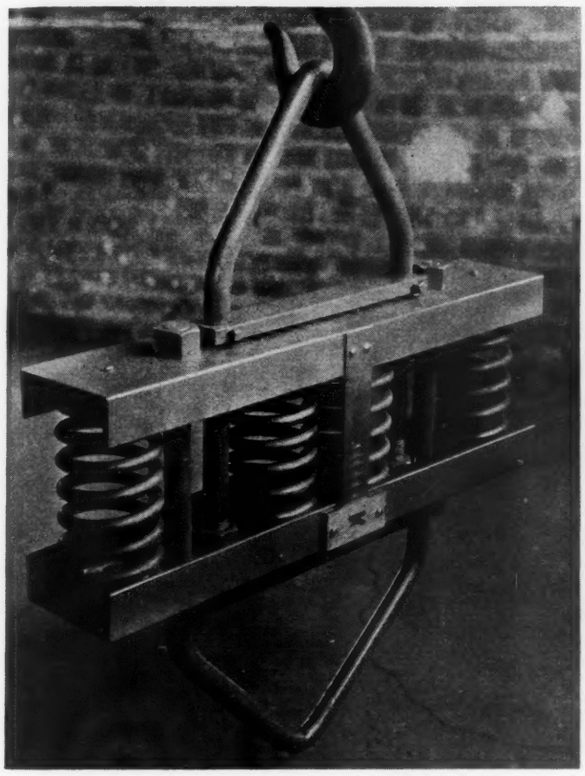
Annual Equipment Index, Another Tool of Engineered Maintenance

WE SHALL include as part of the next issue an index of the announcements of new and improved equipment published during the year 1932. Engineered maintenance requires that those who practice it keep abreast of developments in equipment. The index will provide a quick reference by which the descriptions in the twelve issues of the year can be located.

MAINT-O-GRAPHS

Equipment efficiency ◆ Ideas ◆ Books and events ◆ Plant problems ◆ Design developments

CONTRIBUTIONS ARE WELCOME



Crane Scale Indicates Hoist Capacity Requirements

W. C. Sutton, Plant Engineer
The Lindsay Wire Weaving Company

Two large cast-iron rolls used in our plant formerly were moved by hand chain hoists. When it was decided to replace hand with electric hoists we found that there was no record of the weights of these rolls. Their size, 3 ft. in diameter by 24 ft. long and their location, on the second floor of the building, made it impracticable to move them to our platform scales. We did not consider a calculated weight sufficiently accurate because of their cored construction.

The crane scale pictured was built to determine these weights within an accuracy of 200 to 300 lb. so that we could choose an economical size for the new hoists.

Our calculations showed a probable weight for each roll of about six tons, or three tons on each of two hoists. The helical springs used in our scale were spare parts from other machines. Their size, $\frac{5}{8}$-in. wire, 4-in. mean diameter, $1\frac{1}{4}$-in. pitch, 10-in. free length, we found, by calculation, would allow a maximum loading of about 2,500 lb. each, with a resulting deflection of about $4\frac{3}{4}$ in. Four springs would then be sufficient for our estimated load.

The construction of the 6-in. channel steel frame and $1\frac{1}{4}$-in. rod links is clear from the photograph. Spacers of $\frac{1}{2}$x2-in. steel prevent binding between the links and the channels. Internal plates bolted to the channels serve to locate the springs. The scale indicator operates directly, since the accuracy of calibration did not warrant a multiplying mechanism to give an extended dial.

In calibrating the indicator we made use of a dial type platform scale of 2,000 lb. capacity, and an I-beam lever, arranged for a 3 to 1 ratio. The fulcrum was braced against a ceiling beam, the long end of the lever bore upon the platform scale, and the short end was lifted by a chain hoist through the crane scale being calibrated. For knife edges we used short sections of steel angle. It was necessary to brace the fulcrum post both ways to keep it from kicking out when loaded.

This device accomplished our immediate object very satisfactorily, and disclosed an unexpected variation in weight between the ends of the same roll. It will also be useful for future weighing of heavy parts.

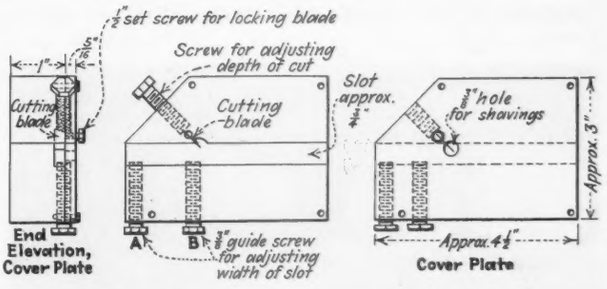
■

Sizing Tool for Forming Retaining Wedges

Samuel Ovando, San Francisco, Calif.

After a motor has been in service for some time the coils and retaining wedges in the stator may dry out and shrink. It is good practice to rewedge machines carefully, in order to prevent chafing of insulation and possible burnouts, when there is reason to suspect such shrinkage.

The tool shown in the sketch will be found handy in forming and sizing retaining wedges accurately. Fiber



strips are first cut in lengths convenient for the shears and about 0.002 in. wider than the finished wedge. These strips are pulled through the groove in the tool, bearing down on them so that they are held firmly against guide

screw *A*. After the strips have been formed on one edge the cutter is readjusted to cut the wedge to the exact width; then the strips are turned over and pulled through again to form the other edge.

It consists of a fiber or metal block containing a groove large enough to accommodate the uncut wedges. In the upper edge of the groove is a slit for a cutting blade which is held in place by means of a setscrew in the cover plate. The depth of the cutter is adjusted by another setscrew, as shown. The upper left-hand corners of the block and coverplate are cut off and, after the coverplate has been screwed tightly to the block, the hole for the cutter adjusting screw is drilled and tapped perpendicular to this bevel, so that the screw is threaded partly in the block and partly in the coverplate.

Two guide screws, *A* and *B*, are provided to support the strip of wedge material. Note that screw *B* is placed directly below the cutter, to prevent the work from springing away from the cutter and chattering.

The cutter is made from tool steel, properly shaped to cut wedges of the desired form, and tempered.

Treatment of wedges in hot paraffin, to prevent shrinkage after the machine is in service, may be given before or after they are finished, but it is advisable to treat the material in strip form before shaping. In this way possibility of warping or variation in finished size, due to the heating in paraffin, may be avoided.

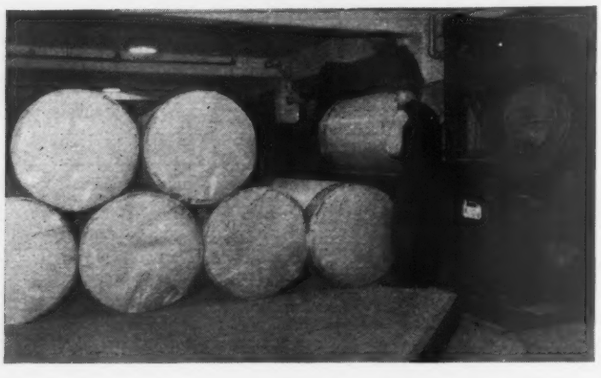
This little tool is light enough to be carried without inconvenience in the ordinary tool bag. It is especially valuable on rewinds in the field where, as often happens, wedges obtained from the shop or the factory may require tedious dressing with a file before they can be used.

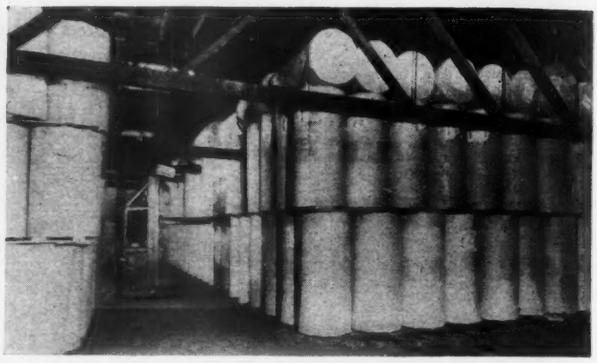
■

Three Examples of Economical Handling

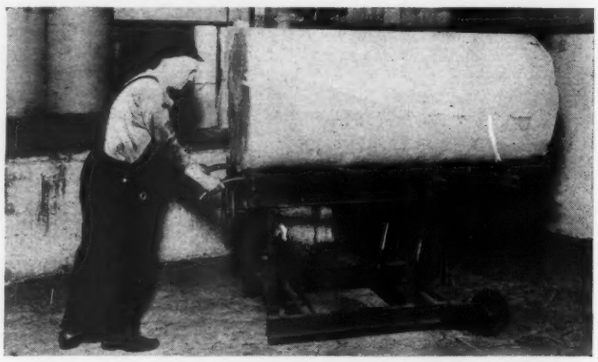
Francis A. Westbrook

Illustrated first is a traction-drive, four-post stacker used by the *Buffalo Courier Express* for tiering and transporting rolls of news print. Two rolls are carried, one on the lift platform and one on the base. The lift platform telescopes with the base during loading. Capacity for lifting is 3,000 lb., for transporting, 6,000, with lifting and traction speeds of 20 and 150 ft. per minute.





The second picture shows a stacker used by the Union Tribune Publishing Co., of San Diego, Calif. It is designed for tiering rolls of paper on end. Capacity is 1,500 lb., and power is furnished by a 5-hp. motor.



Example three shows a truck developed for unloading rolls of paper from one level and standing them on end on a lower level without injury. The paper is rolled off the higher platform to the platform of the truck, which is then pushed to the desired location, where the roll is tipped off—the platform of the truck tips for unloading.

■

Banding a Cracked Flywheel Hub

A. J. Dixon, St. Louis, Mo.

Because of a crack that developed in the hub of the flywheel on a steam-driven air compressor it was necessary to reinforce the hub by shrinking a heavy wrought iron band around each end. The crack, which radiated from a corner of the keyway as shown in the sketch doubtless was caused by applying too much force in driving the key.

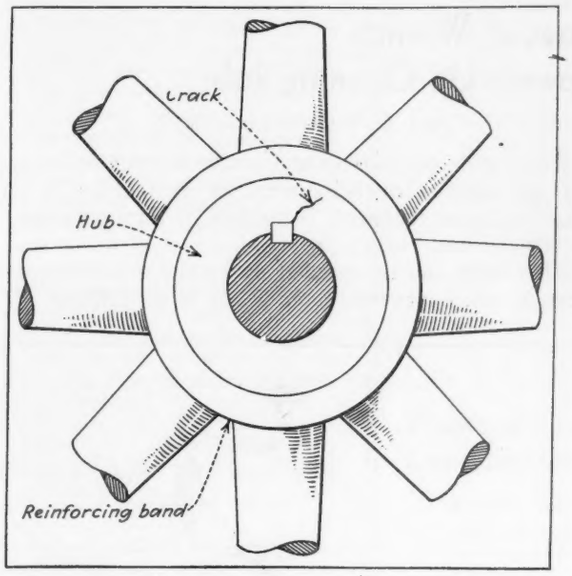
The crankshaft was jacked up high enough to allow sufficient clearance between the bearings and journals for the bands to be slipped on, after which the wheel was securely blocked and wedged and the jacks removed. No obstruction then remained at the outboard end but, in order to band the inner end, it was necessary to remove the crank.

The wrought iron bands were made 1½ in. wide and

3 in. deep. Because the hub diameter was 24 in. it was decided after completion of the following computations to bore the bands to an inside diameter of $23\frac{15}{16}$ in. Their mean circumference when cold, therefore, was:

$$(3.1416)\ (23.9375 + 3) = 84.63 \text{ in.}$$

In order to slip the bands on the hub this mean circumference had to be expanded to:
$(3.1416)\ (24 + 3) = 84.82$ in. Then the total linear



stretch necessary to expand the bands on the hub was:

$$84.81 \text{ in.} - 84.63 \text{ in.} = 0.19 \text{ in.}$$

Then $\frac{0.19}{84.63} = 0.002245$ in. per in., the stretch necessary per inch of mean circumference.

The coefficient of linear expansion per deg. F. of wrought iron is 0.00000648. Assuming an initial temperature of 80 deg., the bands would have to be heated to a temperature of:

$$\frac{0.002245}{0.00000648} + 80 = 426 \text{ deg. F.}$$

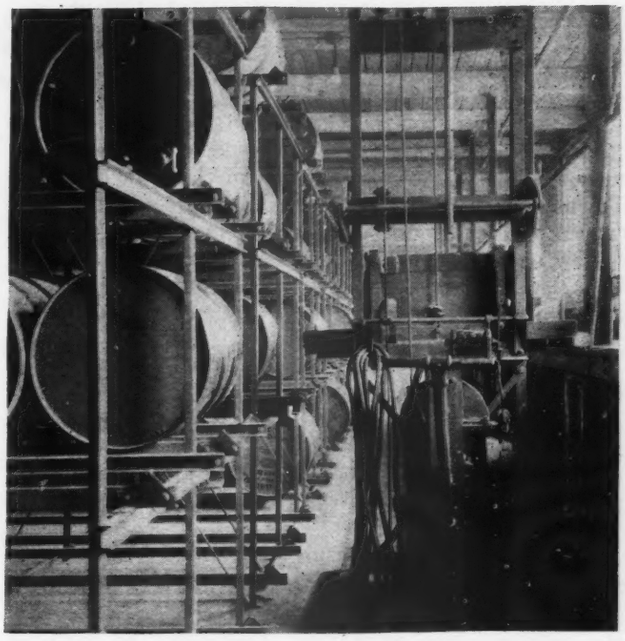
It was seen that the bands could be heated easily to this temperature at which they theoretically would be an exact fit on the hubs. Facility in slipping it on would, of course, call for a higher temperature. Heating the bands to a dull red heat was sufficient to do the job.

■

Simplified Drum Storage

In the plant of the Dewey and Almy Chemical Company, both the amount of space required for storage and the cost of handling steel drums have been reduced considerably by means of the rack, tiering machine, and platform illustrated.

Most of the joints of the structural steel rack are welded. Drums are kept from rolling off the ends by the pivoted angle iron clips shown within the circles. When it is desired to remove a drum from the rack, the



corresponding clips are swung down out of the way, and the drum is rolled onto the portable, electrically operated tiering machine which has been brought into position.

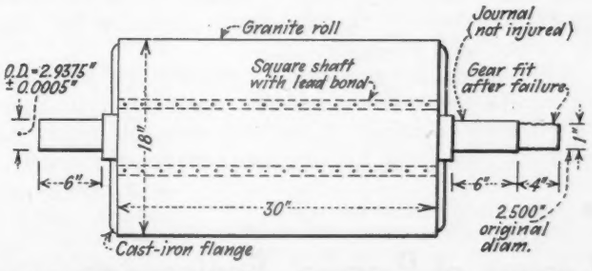
After the tiering machine has lowered or raised the drum to the level of the platform, the drum is rolled upon it. The platform shown is adjacent to, and on the same level as the shipping platform, so that it is necessary only to roll the drums a few feet through convenient doors into the freight cars for shipment. This handling procedure, of course, is reversed for incoming drums.

■

Welding Without Distortion

A. Puishes, Hillside, N. J.

Belief still exists that welding is invariably accompanied by distortion, which must always be removed by subsequent machining. A recent repair job substantiates



my belief that arc welding of machine parts can be done without any distortion detectable by ordinary shop instruments.

This job involved welding the shaft of a granite cylinder 18 in. in diameter, 30 in. long, one of the members of a five-high mill. In a square hole through its center was inserted a steel shaft, whose center portion was also of square section. The steel and granite had been bonded by pouring lead into the square recess.

Journals were accurately ground concentric with the granite to plus or minus 0.0005 in. On one end of the shaft, the driving end, there was a key-seated gear fit $2\frac{1}{2}$ in. in diameter by 4 in. long.

Failure occurred here. Starting in the key-seat a circular section 3 in. long by $\frac{3}{4}$ in. deep peeled off and turned with the gear, leaving a stub 1 in. in diameter. To insert a new shaft and grind the journals true and concentric with the roll would be highly expensive. Possibility of building up the damaged section of the shaft by arc welding was regarded with skepticism because of the accuracy necessary, but this method was used with great success.

The roll was set up in a lathe, with the good end of the shaft in the chuck and the other end in the tailstock center, so that the granite surface and the journals ran true within plus or minus 0.0005 in. as shown by a dial test indicator. A steadyrest was used on the journal next to the tailstock, to relieve the section being welded from any stresses.

An 8-in. length of asbestos pipe covering was placed around the journal next to the weld and provision made for running a continuous supply of cooling water over the asbestos, thus separating (thermally) as much as possible the section being welded from the lead and granite.

Overheating was highly undesirable because of the low melting point of the lead, the expansive qualities of granite, and the fear of distortion. The latter point was especially pertinent since we were not welding on the journal; so any distortion could not be corrected by machining.

The welding machine was grounded to the bed of the lathe and a circumferential bead was run over the damaged section, one man turning the lathe belt by hand while the welder deposited the metal. A current of 150 amp. was used with $\frac{5}{32}$-in. welding wire. Cooling water was supplied continuously and the rates of welding and cooling were so coordinated that at no time was the temperature of the shaft 8 in. from the weld more than 150 deg. Fahrenheit. The bead was built up to a height of $\frac{1}{4}$ in. over the desired diameter of the shaft.

After welding, the two journals and the granite surface were found to run true within plus and minus 0.0005 in., proving conclusively that the entire operation had been performed with no distortion.

After machining the gear fit, turning the shaft, and cutting the key-seat the roll was ready for installation. Satisfactory operation of the mill since this repair was made has established the acceptable quality of the weld.

■

Century of Progress, Engineering Week, and Chicago Power Show

Combined membership of more than 100,000 is represented by the group of engineering societies planning to conduct jointly "Engineering Week" during the Century of Progress next year in Chicago. The week of June 25-30 has been selected. Among the societies taking part will be the American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers.

Obviously the logical time for holding the Chicago Power Show is during this week of engineering meetings. The management promises a show bigger and better than any it has held.

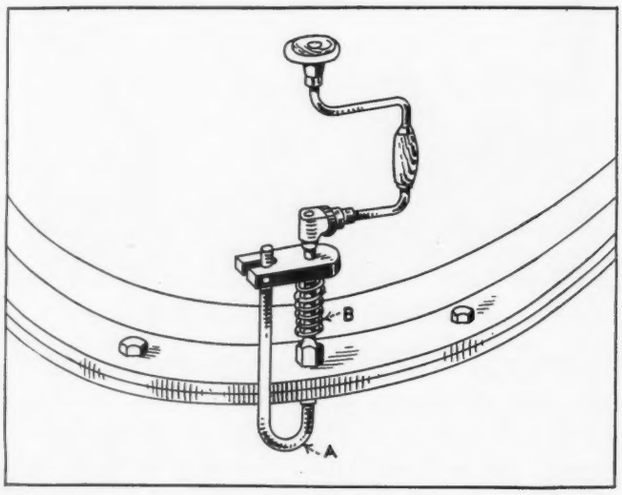
■

Special Wrench Speeds Up Cleaning Job

CHAS. H. WILLEY, Penacook, N. H.

Every time condensers and intake screens are cleaned a large number of bolts must be removed. If such cleaning seems tedious it is because of the time required to remove and replace the bolts.

This work can be speeded up by the use of a special wrench which prevents bolt heads from turning. The



lower section of this tool was made from a socket wrench and is secured to the upper section by the clamp *A* as shown. A spring *B* provides the tension necessary for holding the lower portion in place.

■

Coming Events

Tenth National Exposition of Power and Mechanical Engineering, New York, December 5 to 10.

Eighth Annual Conference on Welding, Purdue University, Lafayette, Ind., December 8-9.

39th Annual Meeting, American Society of Heating and Ventilating Engineers, Hotel Gibson, Cincinnati, Ohio, January 23 to 25.

1933 Convention and Exposition, American Foundryman's Association, Stevens Hotel, Week of June 19.

QUESTIONS and ANSWERS

Conducted by
G. A. VAN BRUNT
Associate Editor

Please submit answers promptly. We expect to publish no answers later than the second issue after the appearance of the question. Selection will be made on the basis of quality, but answers first received have the best chance of being used

■

How Correct Power Factor?

With a total load of 1,100-hp. in induction motors—fractional to 50 hp.—our power factor is 75 and I want to raise it to 90 or 95. Study will doubtless be necessary to determine the best method of doing this, but I should like to know, in general, what factors determine whether synchronous machines or static condensers should be used. There are several separate circuits in the plant: if condensers are used should one or two large ones be put in each circuit, or is it better to use small units at the motors? Is it possible to raise the power factor of the entire plant by one large condenser in the substation? What data are needed in order to determine the most economical method of correction? J.Q.A.

Detroit, Mich.

Changing Motor for Two-Phase Operation

I want to rewind a ⅓-hp., 600-r.p.m., repulsion-induction motor for two-phase operation, 720 r.p.m. There are 44 slots. The core is 5 in. in diameter, 4 in. long. I plan to rewind with coils containing 53 turns of No. 21 s.c.e. wire, pitch 80 per cent, or 1 and 4, ten poles, unequal grouping. The commutator has been short circuited by wrapping No. 17 wire around it. I estimate that the new winding should develop about ½ hp. The fan blades are 32 in. in diameter. I wish readers would tell me whether the motor will work satisfactorily. R.C.

Jefferson City, Mo.

Motor Insulation Resistance

I have been put in charge of maintenance work in a plant in which all motors are tested with an insulation resistance measuring device. We use 220-volt, three-phase, 60-cycle motors. Readings of insulation resistance vary from less than 100,000 ohms to about 800,000 ohms. Will readers tell me (1) what is the minimum safe resistance for 220-volt motors? (2) Should a motor showing this value always be taken out of service at once and repaired? (3) What is the desirable average value of insulation resistance for 220-volt motors, most of which operate under ordinary atmospheric conditions, although a few are in damp places? (4) In general, how often should motors be tested? H.J.A.

Brooklyn, N. Y.

Removing Fins from Commutator Bars

I wish readers would explain the best methods of removing fins from commutator bars after undercutting, covering both square and V-slots. I am especially interested in the methods used by steel mills and railroads. How can this work be done most effectively and economically in a plant containing about 100 d.c. motors up to 25-hp. rating?

Can spiral grooves be cut in an old or newly refilled commutator without elaborate or expensive equipment? R.D.

Chicago, Ill.

Presumably the motors in question which, it is stated, range up to 25 hp., are 1,150 to 1,750 r.p.m. ratings. For such motors we machine in the face of the commutator a square thread that has a pitch of ¼ in. and is $\frac{3}{32}$ in. to $\frac{1}{16}$ in. deep. The groove should be ⅛ in. wide, which leaves the top of the thread also ⅛ in. This work can be done with a square-nosed tool on an engine lathe that is equipped for cutting threads. The spiral grooves can be cut in either old or new commutators. The commutator should be turned true and undercut before the spiral groove is machined. The groove will be a single-thread screw.

It is our practice to remove mica fins from commutator bars after undercutting with a sharp tool by hand when necessary. We machine only square slots. If the undercutting tool is but a trifle wider than the mica and the undercutting machine is lined up true, the experienced operator will have little difficulty in removing all of the mica on the machine and usually no hand work will be necessary.

A V-slot between commutator bars is more likely to cause mica fins to be present, especially after the commutator wears a little, than is the square slot. Our experience has been that the V-slot is not so satisfactory as the square slot and we do not use it.

C. B. HATHAWAY.

Section Engineer,
Industrial Motor Engineering,
Westinghouse Electric & Manufacturing Co.
East Pittsburgh, Pa.

■

How Control Maintenance Department Tools?

We are making a survey of our maintenance tools and equipment and the system of controlling them, and should like to know the practice of other companies on these points:

1. What method of control is used for company-owned tools and equipment?

2. What tools are furnished to millwrights, carpenters, electricians, and other maintenance workers?

3. What arrangements are made for employees to borrow company-owned tools for personal use after regular working hours?

4. Are departmental foremen furnished tools for miscellaneous maintenance work in their department?

5. What tools are furnished machine operators (not machinists or tool makers)?

6. If a maintenance tool is broken by an employee's negligence or misuse, is he required to replace it? W.T.A.

Decatur, Ill.

Methods we use for controlling company-owned tools and equipment are:

1. Each workman in the maintenance department is provided with a set of metal tags or checks bearing his number and he uses these to obtain company-owned tools. These tools are kept in

the maintenance department storeroom and issued by the storekeeper. They must be returned before quitting time each evening.

2. It is the custom for carpenters, millwrights, and machinists to supply their own fine tools; company-owned tools consist mainly of such items as hammers, wrenches, drills, hacksaws, electric drills, air hammers, and the like.

3. The company does not lend tools for personal use after working hours.

4. Departmental foremen are not furnished with tools, since all the adjustments and repairs are made by the maintenance department.

5. No tools are supplied to machine operators.

6. Maintenance department employees are charged with the cost of any tool broken or lost through their carelessness. It is seldom necessary to do this, however, as our men are trained to take the proper care of company equipment.

C. W. SCHWABE.
Superintendent of Mechanical Department
Mallinckrodt Chemical Works
St. Louis, Mo.

Shops have various methods of handling tools. From my experience I would answer W.T.A.'s questions as follows:

1. The tool room and check system seems to be the best. Even in very small plants where a clerk or the timekeeper is placed in charge either all day or at stated hours, it is good economy.

2. Company-provided tools usually consist of heavy hammers, pipe wrenches, bolt cutters, all drills, reamers, and taps, special tools, and all instruments such as voltmeters, precision levels, pyrometers, large micrometers. The men bring their own hand hammers, calipers, surface gages, rules, small chisels, pocket pliers, light wrenches, and so on.

3. It is common practice to allow the men to borrow for home use such company-owned tools as pipe wrenches, post-hole diggers, jacks, large saws, blast lamps. Probably the best procedure is to permit the foreman to make out an order to the tool room for the loan; the tool room man passes the items out on the regular checks. It should be a rule that the tools must be brought back to the shop the next morning even if the job is not finished, because the shop must not be handicapped in case those tools are needed. Of course, there may be exceptions to this rule, as for example, in the case of a man using some jacks to level up the floors of his house.

4. It is customary to furnish departmental foremen with necessary or convenient tools.

5. Machine operators are usually expected to bring their own hammer, calipers, scales, depth gage, and such necessary standard tools as will go into a small tool box. Large or special tools, gages, etc., are provided.

6. If a tool breaks under ordinary conditions of use, including such items as an occasional broken hammer handle or hacksaw blade, the company makes the replacement. If a workman actually abuses tools, such as making an 18-in. pipe wrench into a 36-in. by jamming a piece of pipe on the handle, or by using a ½-ton block for a 1½-ton load, he should pay the actual cost of putting the tool in good repair. Sometimes a man may be on an emergency job and through the absence of proper tools has to take a chance on abusing those at hand. These cases must be judged on their merits. Generally speaking an alibi of this kind is not acceptable unless the man has obtained his foreman's permission to go ahead.

In case of breakage it is usually better to charge the man for putting the tool in proper condition rather than for the cost of a new tool. No one will kick on the cost of repairs, but many arguments are brought up or an unsatisfactory mental state may be developed about the brand new tool bought by a workman to replace one that was "about worn out anyway."

Moline, Ill. GEO. P. PEARCE.

All company-owned tools should be kept in a toolrom fitted with racks, bins, and hangers, so that they may be found readily when needed. This room should be in charge of a full-time storekeeper who is familiar with all types of tools and their uses. He should be competent also to re-condition and repair the tools in his care, and should be provided with grinders and such tools as may be necessary to keep the stock in good shape. In a plant of any size this duty will entail full-time work.

Issuance of tools is best controlled by means of the check system. Under this system every maintenance department employee who is a journeyman mechanic is provided, when he joins the company, with a number of brass checks bearing his payroll or clock number. These checks are kept in the private tool box of the employee to whom they are issued. When a workman requires a company-owned tool he surrenders one of these checks to the toolroom attendant in exchange for the tool. The bin or rack from which the tool is taken is provided with a small brass cup hook on the front on which the check is hung, and there it remains until it is redeemed by the return of the tool. When any employee quits the company's service he must hand over the same number of checks issued to him in the first place. Should any tool be lost or purloined a check will be found in the bin from which it was issued, and the responsibility for loss is at once definitely established.

This is a broad outline of a system that has worked very well in a large number of plants; it can be adapted to suit the conditions of industrial works of almost any size.

The usual practice is for the company to provide all special tools and appliances, and the heavier and more expensive common tools. Included are portable electric and pneumatic tools, drills, taps, dies, large pipe and other wrenches, heavy soldering furnaces, the large and more expensive sets of micrometers, special gages, and so on.

Tradesmen such as carpenters, millwrights, machinists, electricians, plumbers, and bricklayers are expected to provide themselves with a good kit of hand tools. It is the practice in many places to allow the men to purchase tools through the company at wholesale prices, in some cases at slightly below wholesale, to encourage the men to keep up a good kit of tools.

Borrowing company-owned tools for personal use is largely a matter for the discretion of the maintenance or plant engineer; no definite rule can be laid down. It is essential that such tools should not be borrowed without the express permission of the responsible person in charge of them and it is preferable that such permission should be in writing.

If an adequate and efficient maintenance department is functioning in the plant, there should be no necessity for the issuance of tools to department foremen.

Machine operators should require no tools other than the wrenches needed for the operating adjustments of the machine. Any repairs necessitating the use of other tools should be handled by the maintenance department.

Responsibility of employees in case tools are broken is governed largely by conditions in individual cases and should be a matter for the decision of the plant engineer. G. NOBLE.
Mountain Park, Alta., Canada.

■

Rewind with Asbestos Wire?

We are having what seems to be an excessive number of breakdowns on motors operating in hot places, such as on vacuum pumps, near baking ovens, and on stokers. The possibility of rewinding these motors with asbestos wire has been considered, but we have had no experience with this material and wonder whether the higher first cost would be justified by the performance. Also I should like to know (1) whether asbestos wire is more difficult or expensive to handle when rewinding a motor than is cotton-insulated. (2) As compared with ordinary wire, how much longer can asbestos wire be expected to last under high motor operating temperatures? (3) What is the maximum safe operating temperature for a motor wound with asbestos wire? M.P.
New Haven, Conn.

Asbestos-insulated wire is without doubt the answer to the problem of winding motors to stand up under excessive heat. Even though the heat present may not be enough to char other insulation the oxidation process that eventually causes an insulation failure, is speeded up, necessitating a premature winding job. Since asbestos is for all practical purposes unaffected by heat it is the ideal insulation for motors operating under hot or unusually warm conditions.

Manufacturers of wire have long realized that asbestos was the logical insulation for motors in unduly hot places. The problem was how to apply it to the wire. Asbestos has a relatively short fiber and is not so adaptable for this purpose as cotton. The first asbestos-covered wire was difficult to handle, particularly if winding space was limited. The least bit of abrasion or pounding would cause the covering to slip. Winders accustomed to using cotton-covered wire had lots of trouble with asbestos-covered; consequently it received a bad name. Many of them are still loathe to recommend it.

Better methods of manufacture have improved asbestos insulation to the point where the best grades of asbestos-insulated wire are just as easily handled as cotton-covered, if not more so. There is no reason why any experienced winder should have trouble with it.

The cost of asbestos-covered wire is slightly higher than for cotton-covered, but the higher cost is more than justified for use in places where excessive heat is encountered. Burned-out windings due to heat can be practically eliminated. If bearings are allowed to wear down too far, that is a different story. The winding will be ruined the same as though other insulation were used, but that is through no fault of the insulation.

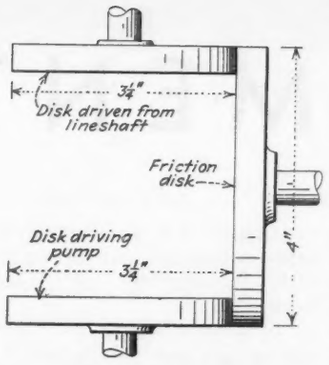
It is assumed, of course, that the wire used will be purchased from a reputable manufacturer. If this is done and the recommendations of the manufacturer are followed in its use, rewinding with asbestos-covered wire will prove to be a good investment. There are different types and grades of asbestos-insulated wire for different operating conditions. These types are the result of study and experiment and each one is best for the particular use for which it is designed. Manufacturers will gladly furnish this information to anyone interested, so that winding with asbestos-covered wire need not be guesswork. W. L. COTTON.

Electrical Department,
Rock Island Lines,
Dalhart, Texas.

■

Friction Drive for Pump

Can some reader tell me whether I can obtain 1½ or 2 hp. from the friction drive shown in the drawing?



How wide should the faces of the upper and lower disks be? What material is best for facing the disks? I want to use this drive for operating a small pump from a lineshaft.
Milwaukee, Wis. J.A.

The friction drive shown could scarcely be expected to transmit much more than ¼ horsepower. Because power has to be transmitted through two friction surfaces it is impracticable to use any material other than metal for the three disks. The driving disk, of course, could be faced with some friction material since it is the source of power, but this expense would not be justified because the intermediate disk could not be so covered and the power transmitted would then depend upon the friction between the intermediate and the pump-driving disks.

In these types of drives it is not practicable to use a friction covering such as rubber, leather or fiber, on a driven surface since the moment the driven disk slips the driver immediately wears a flat spot or depression in the soft material and the drive is ruined. Thus one is restricted to a good wearing metal for the three disks. My experience in designing small friction drives and clutches has been that for a drive of this nature cast iron gives the best all-round results.

Width of the disk is the next thing to consider. Unfortunately in the design shown the width cannot be very great on account of the difference in speed between the upper and lower edges of the disks and the face of the intermediate. Even for a width of ⅜ in. there will be a speed difference of almost 20 per cent, which will cause heating and wear. Since it is desired to obtain all the power possible, however, assume the width of the face to be ⅜ in. The maximum pressure that we dare to put on the line contact between the edge of the disks and the face of the intermediate must be considered next. A thousand pounds per lineal inch would be in excess of the pressure allowed by good design but probably the cast iron would stand it without crumbling; so we will assume that pressure. On ⅜ in. the pressure would be 375 lb. The coefficient of friction for dry cast-iron surfaces is sometimes taken as 0.15, although 0.1 is more frequently used. Using the higher figure the torque on the intermediate disk will be, 375 lb. × 0.15 = 56.25 lb. If the power losses on this disk are ignored it can be assumed that the intermediate disk transmits this torque to the rim of the pump disk.

The speed is not given by J.A. However, it is a lineshaft drive; so we can assume it is a high-speed lineshaft running at, say, 300 r.p.m. Thus there is a 3¼-in. diameter disk revolving at 300 r.p.m. with a torque of 56.25 lb. at its circumference. The transmitted horsepower is therefore, $3\frac{1}{4} \div 12 \times \pi \times 300 \times 56.25 \div 33{,}000 = 0.436$ hp. at 100 per cent efficiency. There will, however, be considerable loss due to friction and if ¼ hp. is actually delivered to the pump it will be doing very well.

It will be better for J.A. to lay out a different design of drive for his small pump. GEO P. PEARCE.

Moline, Ill.

The device shown is entirely too small for the estimated power unless the speed, which is not given, is impossibly high. Marks' Handbook says that the width of friction disks should not exceed 1/12 of the radius at which they are operated, which would make them ½ in. wide in this case, as otherwise the slip and wear due to the difference in speed of the inner and outer edges will be excessive. Certain constants based on the crushing strength of the facing materials and their coefficients of friction also are given. Taking the highest value of these factors and assuming a speed of 1,000 r.p.m. the formula is Hp. $= 0.00059\ w\,d\,N$, where Hp. is horsepower transmitted; w the width of the friction disk face in inches; d, its diameter; and N its speed. In the present case, Hp. $= 0.00059 \times \frac{1}{8} \times 3\frac{1}{4} \times 1{,}000 = 0.32$, which shows that all dimensions should be increased greatly. This calculation applies to a leather fiber disk and cast-iron wheel.

A bad feature of the arrangement shown is that in order to avoid flat spots in case of slippage each driver disk should be of softer material than its driven disk. The lineshaft disk would have to be made of quite soft material, and the one marked "friction disk" of an intermediate quality; then the "disk driving pump" might be cast iron. Just what range of hardness can be obtained in commercial materials is difficult to say. Possibly a rather soft rubber composition might be used for the lineshaft disk, a hard, vulcanized fiber for the friction disk, and cast iron for the pump-driving disk.

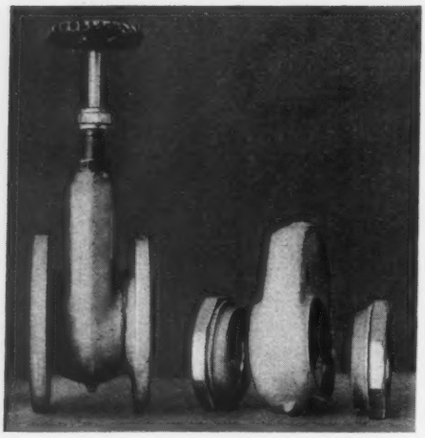
I would strongly recommend to J.A. that he try to adapt a belt drive to this application, although it is impossible to advise him properly since no information is given as to the space available and whether some speed variation is necessary. H. D. FISHER.

Plant Engineer,
New Haven Pulp and Board Company,
New Haven, Conn.

EQUIPMENT NEWS

Gate Valve

A light-weight valve without bolted or threaded bonnet, the bronze disk being installed through the flow passage. Opposed threads lift the disk, which is of the self-aligning type. Disk seats are integral with the ends, which can be flanged, threaded internally or externally, or made with any combination of



flanging and threading. Weight of 2½-in. size is 6 lb. in aluminum, 13 lb. in bronze. Shand & Jurs Co., Berkeley, Calif.

■

Rubber Tires for Wheelbarrows

Low pressure tires, patterned after airplane casings. Advantages claimed: Use in mud and deep sand; reduced manual effort; less breakage in fragile loads. B. F. Goodrich Co., Akron, Ohio.

■

Automatic Nut Lock

A locking device applied to the nut by the manufacturer of the lock. Process of application said to make the lock an integral part of the nut. Applicable to ordinary and heat-treated bolts, and for S.A.E. thread where standard nut blank is used. Easy unlocking and no reverse turning due to vibration claimed. Known as "Cole's Automatic Nut-Lock." Sole distributor, Ohio Equipment Co., Inc., 5716 Euclid Ave., Cleveland, Ohio.

■

Air Conditioning Equipment

The Cooling and Air Conditioning Corp., founded by and until recently partly owned by the B. F. Sturtevant Co., is now a completely owned Sturtevant subsidiary. The name of the corporation will be changed to Sturtevant-Cooling and Air Conditioning Co., with headquarters at Hyde Park, Boston, Mass.

Sturtevant-Cooling and Air Conditioning Co. will handle public building conditioning and comfort work and also process work of the system type, applicable to industrials.

The B. F. Sturtevant Co. will handle the manufacturing and sale of the unit type of air conditioning product, such as coolers and humidifiers, or combinations of both.

■

Capacitors

Treated and filled with Pyranol, a recent dielectric material that is non-flammable, non-explosive. Size, rating for rating, has been reduced. Line also includes new box-type units, and small rack-type capacitors, for power factor correction, indoor service.

Box-type capacitors, for indoor service, can be connected directly to motor terminals or to line side of motor switch. Units inclosed in welded steel cases, provided with conduit boxes.

Small, rack-type units are an innovation. Racks and individual units provided with fuses can be combined as desired over wide range of kva. ratings. General Electric Co., Schenectady, N. Y.

■

Soldering Flux

A white, creamy chemical, shipped in 12-lb. cans and 60-lb. pails, that is brushed on the metal to be soldered. Trade name "Flosol Cream." Drying time 10 to 15 min., but soldering can be done before or after drying. Said by manufacturer to flux most of the commonly used metals except aluminum and its alloys. American Chemical Paint Co., Ambler, Pa.

■

Water Softener

Industrial zeolite water softener, automatic by means of a combination of meter operated switch and electric controls with a motor-driven single valve. At the end of the softening run, the meter actuates the electrical controls which carry through the steps of cutting the softener out of operation; backwashing it for a regulated period to secure cleansing; admitting a regulated amount of saturated salt brine to assure regeneration; rinsing out the hardness salts to waste; and throwing the softener back into service. The automatic control can be applied to existent downflow softeners. The Permutit Co., 440 Fourth Ave., New York, N. Y.

■

Storage Battery

A liquid-bound, non-spill, dry storage battery known as "Rechargit." Has the usual lead-sulphuric acid couple but is made liquid-bound through the use of an insulation which holds a quantity of electrolyte in absorption.

A small quantity of distilled water is added to the cell at time of charging, which is done with any standard charger in 10 to 12 hours. At the end of the charge any excess liquid is drained off. N. D. Sturges, Inc. Distributor, Lee Skipworth & Co., Inc., 369 Lexington Ave., New York, N. Y.

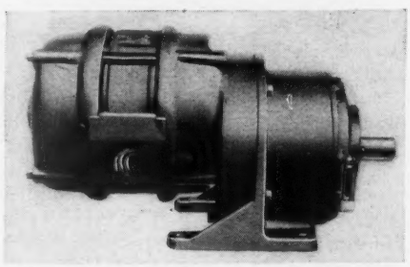
■

Geared Motors

Gear reduction unit is built integral with the motor, the high speed gear being mounted directly upon the motor shaft. Available in ratios from 2.09 to 1 up to 376 to 1, giving output speeds of from 861 to 4.7 r.p.m. with the 1,800-r.p.m. motor supplied.

Depending upon the reduction, the reducer consists of a single-stage helical gear unit, a two-stage helical gear unit, or one stage of helical and one stage of heliocentric gears Units with heliocentric gears (illustrated) have the motor hung on the reducer, other units have the reducer hung on the motor.

Horsepowers from ¾ to 20, open or



inclosed type motors, for two or three-phase a.c., or d.c. The Ideal Electric and Manufacturing Co., Mansfield, Ohio.

■

Splash-Proof Motor

Built in the same dimensions as standard open motors. A double baffle in an elliptical-shaped air passage in each endbell provides the protection. This construction, while permitting free pas-

sage of ventilating air, traps and drains water splashed into the air openings at the bottom of the elliptical-shaped chambers. A shaft guard breaks the force of a stream directed along the shaft extension and prevents water from entering the bearing chamber. The Louis Allis Co., Milwaukee, Wis.

■

Oil Cup With Filter

Glass drip cup, with inverted cone filter of impregnated felt in bottom. The oil passes up through the filter and out through the exit hole in needle valve tube to the bearing. H. B. Morrow Co., Mishawaka, Ind.

■

Induction Type Pressure Governor

For automatic control of motor-driven pumps. Claimed: Sensitive to minute variations in average pressure, but is not affected by pressure surges.

Operates on the induction principle; has no electrical contacts except mercury pilot switch. Capacity of pilot switch ranges from 10 amp. at 110 volts to 2.5 amp. at 440 volts.

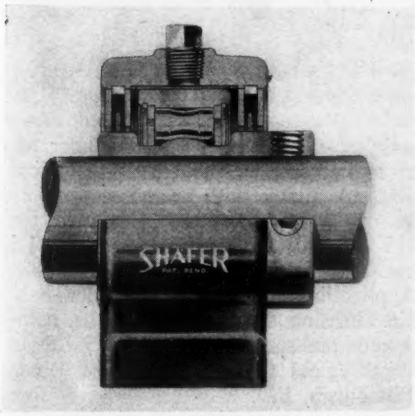
Model A governor has adjustable range of 20 to 230 ft. of water; adjustable differential of 0.3 to 35 ft. Other pressure ranges available. Consolidated Electric Co., St. Paul, Minn.

■

Roller Bearings

Single row, self-aligning, radial roller bearings. A concave bearing is used, with rollers operating between a straight outer race and a convex inner race. This design is followed to assure liberal radial load capacity with provision for the limited thrust capacity needed in applications having moderate loads.

Self-alignment is obtained within the bearing, to compensate automatically for misalignment caused by inaccuracies in machining or shaft deflection under load. With this full roller type bearing the retainer is omitted. Thrust is taken by means of hardened and ground thrust plates.



Available in the pillow block illustrated, in flange units, hanger boxes, take-up units, and separately. Shafer Bearing Corp., 621 S. Kolmar Ave., Chicago, Ill.

■

Sawing Vise

For ⅛- to 2-in. thin-wall copper or brass tubing. Made of aluminum with steel inserts. Clamping is by reversible vise block and thumb screw. Tubing is centered in a V trough, and a guide prevents the saw from "running." The Borden Co., Warren, Ohio.

■

Vertical Gas Engines

Four-cycle with one to eight cylinders and 30 to 150 hp. per cylinder, giving a range of 30 to 1,800 hp. Can be converted to Diesel operation.

A mixing valve, common to all cylinders and adjustable through a knurled handscrew, is employed on all but the largest units. Separate air and gas mixing valves, independently adjustable for each cylinder, are installed in each cylinder head of the largest engines. In all but the smallest units, air inlet and exhaust valves are carried in removable and interchangeable cages, the exhaust valve cages being water cooled; in the smaller engines, these valves (which are also interchangeable and adjustable) seat directly in the cylinder head and operate in removable bushings.

An attached reciprocating pump circulates lubricating oil through a cast-in duct in the base with cast-in branches leading to the bottom of each main bearing. Through drilled passages in the crankshaft and connecting rods, the oil reaches the crank and wristpin bearings under pressure from the main bearings. Camshaft gear, governor, and all other points requiring lubrication are supplied with oil under pressure from the flywheel end of the main oil duct. Two-point force feed lubrication of the cylinders is employed on all but the smallest units. The camshaft is driven from the flywheel end by spur gears with silent spiral teeth. Worthington Pump and Machinery Corp., Harrison, N. J.

■

Radiators

Additions and new models to "High-Convection" line for steam and hot water heating, cooling, drying. Features include welded construction, self draining of tubes, light weight (2 lb. per sq.ft.). Available in lengths of from 2 to 16 ft., suitable for floor, wall, ceiling, column, pilaster, monitor, shelf and under bench installation. Shaw-Perkins Manufacturing Co., Oliver Bldg., Pittsburgh, Pa.

Magnetic Switches

A line of full voltage magnetic switches built to the standards of the Underwriters' Laboratories for industrial control equipment for use in Class I, Group D hazardous locations. Weatherproof, suitable for use in corrosive atmospheres.

The devices consist of standard G.E. magnetic switches with special operating coils and special contact tips for operation under oil, and an oil-immersed temperature overload relay. The General Electric Co., Schenectady, N. Y.

■

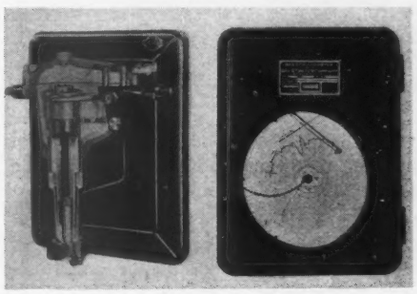
Fluid Hose

For resistance to solvents, such as oils, gasolines, and lacquer thinners. Uses a liner of "Thiokol." Maker reports desirable resistance to bending, twisting, and wrenching. De Vilbiss Co., Toledo, Ohio.

■

Fluid Meters

For the measurement of steam, water, gases, and other fluids. Three general combinations are available: indicating and integrating; recording and integrating (illustrated); indicating, recording, and integrating. The record is made in pounds per hour, gallons per minute, or any other desired units on a 12-in., 24-hr. chart. The flow graduations are uniformly spaced. Records of pressure



and temperature may be obtained on the same chart by incorporating auxiliary recorders in the flow meter casing. The total flow is given in pounds, gallons, or other units by a 6-unit counter located behind a small window in the meter name plate. Bailey Meter Co., Cleveland, Ohio.

■

Portable Electric Saw

Light weight, and measuring 12 in. over all. Known as "Skilsaw Model W." Makers recommend for 1-in. lumber, cross-cutting up to 2x12-in. dressed lumber. Blade 6 in. in diameter, cuts 1⅞-in. deep. Base is vertically adjustable for depth of cut. Guarded. Universal motor, 110 volts, ⅓ hp. Thumb operated switch of the momentary safety type. Skilsaw, Inc., 3814 Ravenswood Ave., Chicago, Ill.

Switchboard Instruments

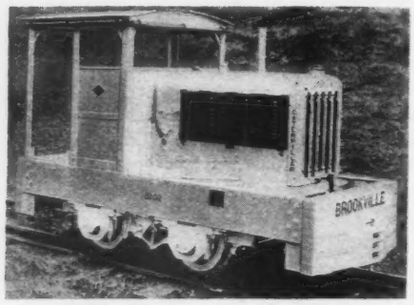
With square cases, to utilize minimum of switchboard space. Designated H line. Includes ammeters, milliameters, voltmeters, milli-voltmeters, single and polyphase power factor meters, frequency meters, synchroscopes. Both a.c. and d.c. instruments intended for service on large switchboards of steel, ebony asbestos, or slate. Radio frequency and rectifier designs available for low-energy a.c. applications. Case 5½ in. square, 4 7/16 in. deep, uniform size throughout line.

Long scales facilitate reading at distance. Retain fundamentals of design used in previous instruments, but have been designed with greater overload capacity. Westinghouse Electric & Manufacturing Co., Newark, N. J.

■

Industrial Locomotives

"BCL" series, using Caterpillar engines. Available in 5, 6, 7, 8, 10 and 12 tons weight for all track gages. Four operating speeds both forward and reverse, range 2 to 15 miles per hour. For



gasoline fuel, with kerosene or alcohol burning equipment optional. Brookville Locomotive Co., Brookville, Pa.

■

Key Lock

Known as the "Dualock." Employs the pin tumbler principle, with key duplicable accurately only by the manufacturer, it is claimed. Can be masterkeyed, with masterkey registered to the installation, duplicates to be ordered on identification and authority. Dudley Lock Corp., 26 N. Franklin St., Chicago, Ill.

■

Horizontal Steam Pumps

For handling water or chemical solutions; built in three types: valve plate, turret, and pot valve. Stainless steel, drop forged, valve service, adopted on all models. All units are standard fitted with forced-in liners for water service, iron fitted for brine and caustic solutions, and all-bronze for handling acids.

Valve plate type pumps have discharge valves screwed into a common removable deck. Suction and discharge valves are above the cylinders. Available in capacities from 5 to 320 g.p.m., at pressures up to 250 lb. per square inch.

Suction and discharge valves on turret type pumps are cast integral with the cylinders. Suction valves are accessible through handhole plates, and discharge valves through top cover. Stuffing boxes are bolted, with bolted glands. Capacities from 150 to 840 g.p.m., pressures up to 200 lb. per square inch.

Pot valve pumps, all with submerged pistons, come in three types: for pressures up to 500 lb. per sq.in., capacities 40 to 96 g.p.m., with special steam end with suction valves accessible through discharge valve seats; for boiler feed service, capacities from 15 to 760 g.p.m., pressure up to 300 lb. per sq.in.; for pressures up to 500 lb. per sq.in., capacities 140 to 1,800 g.p.m.; cylinders are fitted with bronze liners and stainless steel liquid piston rods. Worthington Pump & Machinery Corp., Worthington Ave., at Warren St., Harrison, N. J.

■

Ball Bearing Pedestal

A line of unit pedestals for pillow blocks, designated as the "LUP" series, and adapted to all average industrial requirements, in sizes to fit standard shafting in nominal inch as well as sixteenth diameters, from 1/8 in. to 3½ in. The ball bearings are the standard Norma-Hoffmann "Precision" double-row self-aligning type with adapter sleeve. Pedestals have capacity for a large volume of lubricant, with fittings for replenishing as needed. Protecting felt seals prevent escape of lubricant along the shaft. These pedestals may be had with the bearings either floating or fixed in the housing. In the latter case, suitable distance pieces are furnished for clamping the outer ring. Norma-Hoffmann Bearings Corp., Stamford, Conn.

■

High-Temperature Paint

Designed for application to equipment coming into contact with intense heat, such as furnace doors, rotary kilns, engine exhaust manifolds. Said to withstand temperatures of from 1,400 to 1,800 deg. F. Made in black, red, white, green, gray. Known as "Laclede C-10 High Temperature Paint." Packed in containers holding from 1 qt. to 50 gal., in liquid form. Laclede-Christy Clay Products Co., St. Louis, Mo.

■

Electroplating Generator

Separately-excited, compensated to control voltage drop under load. Claimed: voltage may be set for any required drop, for a constant no-load to full-load voltage, or for an increasing voltage on increasing load. Compensating effect is produced at all voltages within the operating limit of the machine. Compensator circuit and generator field circuit are separately adjustable; neither affects proper functioning of the other. Columbia Electric Mfg. Co., 1292 East 53rd St., Cleveland, Ohio.

■

Electrode Holder

For atomic-hydrogen arc welding with flexible tungsten electrodes. These are carried in curved tubes, forming part of holder, and brought into position by screw feed ejector.

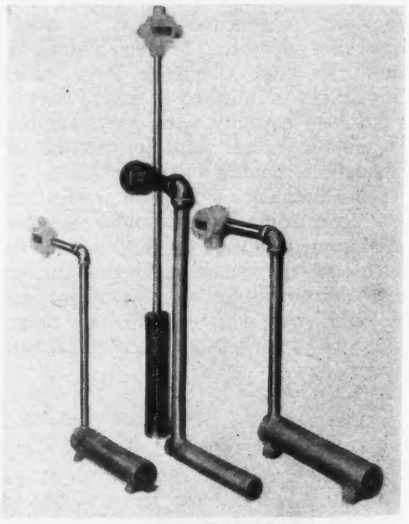
Flexible tungsten electrode is made up of small-diameter tungsten wires stranded together. Consumption same as rod type.

Advantages claimed: Electrode easily adjusted, can be consumed to length of 1½ in.; hydrogen tubes easily detached from handle; all wearing parts arranged for quick, easy replacement; adjustment for controlling position of welding flame. General Electric Co., Schenectady, N. Y.

■

Electric Immersion Heaters

Heavy-duty service. Heating element imbedded in refractory material under hydraulic pressure, baked at red heat; incased in steel, cast-iron, wrought-iron,



stainless-steel, Monel metal, copper, or brass housing as required by application. Available with heated sections 2½ in. or 3½ in. diameter. Designed for 115- or 230-volt service. Ratings: 1.5 kw. to 5 kw.; other ratings available. Applications: Melting lead, solder, babbitt; heating salt baths, oil baths, compound tanks, pickling baths. Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh, Pa.

Midget Photoelectric Relay

Designated CR7505-KL. Consists of phototube, Pliotron amplifying tube, sensitive relay, adjustable potentiometer, and associated apparatus, mounted on steel base.

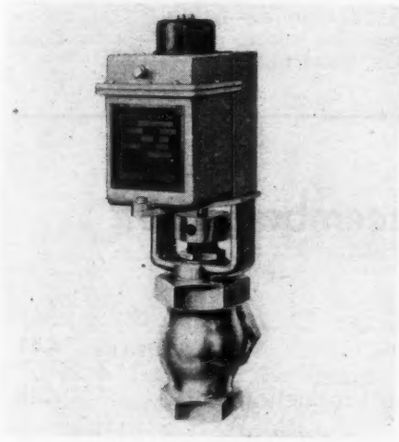
Applicable when changes of light intensity of at least 50 per cent are made. Particularly adaptable to counting; relay will handle directly usual types of magnetic counters. Operates on light impulses of one-fifteenth second duration.

Unit is complete in itself without enclosing case, but a drawn case is provided to allow mounting on vertical support. General Electric Company, Schenectady, N. Y.

■

Electric Throttling Valve

Designed for use where graduated valve action may be required, for example on small blast and air conditioning systems, and with unit heaters and unit ventilators. Available in packed or packless models, high or low pressure types, sizes ½ to 2 in. The motor-operator used is a small size reversing damper controller by the same manufacturer. Barber-Colman Co., Rockford, Ill.



■

Bottle Oiler

Made up of three major parts: glass bottle with threaded neck, bronze base with integral sleeve type shank, and brass feed wire. A cork washer seals the joint between bottle and base. Automatic in operation, feeding only when the shaft is in motion. The Lunkenheimer Co., Cincinnati, Ohio.

■

Motor Reduction Unit

For use where low speed drives are required. A standard round frame type motor is mounted directly on the gear reducer housing. Helical gears are used. Standard speeds at the power take-off are from 3.02 to 380 r.p.m., but lower speeds can be provided; 6.08 r.p.m. is obtained with the use of a 1,750 r.p.m. motor.

The bearing supporting the gear drives are ball or roller type. Lubrication is automatic. Standard units are arranged for floor mounting. Units can be supplied for wall, ceiling, or vertical mounting. Any desired type of motor may be supplied. Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

■

Circuit Breaker

Three-pole, non-oil-throwing type, indoor service, oil immersed. Features: Welded square tank of reinforced, heavy steel plate with full rounded corners; interior lined with arc-resisting material; straight-line-motion mechanism of non-magnetic steel parts operates under Everdur domed tank head, eliminating magnetic heating; terminals and bushings made of copper bars wrapped with impregnated, bakelized paper; breaker lift rods travel through roller guides. Rated, 5 kv., 3,000 amp., 50,000 kva. Delta-Star Electric Co., 2400 Fulton St., Chicago, Ill.

■

Conveyors

For "en masse" handling. Principle of operation was developed in England, now being introduced here. Conveyor consists of steel cable or chain fitted with heart- or H-shaped "verticals" or conveying links, spaced short distance apart, running in rectangular, closed trough. Material is conveyed in solid stream with little relative movement between particles. Friction to be overcome is mostly between moving material and sides of trough. Material can be conveyed at any angle from horizontal to vertical. Claimed: dustless operation; gentle handling; freedom from overloading; saving of space; low power consumption; flexibility. The Redler Conveyor Co., 117 Liberty St., New York, N. Y. Pneumatic Scale Corp., Ltd., Norfolk Downs (Quincy), Mass., licensee.

■

Motor-Operated Three-Way Valves

Arranged to be opened and closed by an electric motor-operator unit mounted in place of the customary handwheel. Valves are of conventional three-way type and are available in sizes of from ½ to 2 in., with either positive or reversing operator. The same company's shaded pole induction motor is used in the operator. Valves may be controlled from manual or automatic switch, or from thermostat. Power required is 25-volt, 60-cycle a.c. Barber-Colman Co., Rockford, Ill.

■

Belting

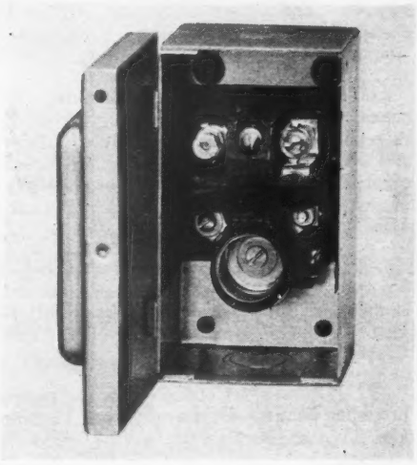
Known as "Compensated" belt. Features claimed by the manufacturer include transmission of power with very low tension, creep, and slip; pulley surface with high coefficient of friction; "compensation" for operation on very small pulleys; equalized tension of outside and inside duck plies, with elimination of loose fasteners. Manhattan Rubber Manufacturing Co., Passaic, N. J.

■

Disk Switch

Designated Catalog No. 90211. Dimensions: 5⅜ in. high, 3⅛ in. wide, 2¾ in. deep. Capacity 30 amp. or 1 hp. at 125 volts. Two-pole, one fuse, one blade, solid neutral.

Front operation; small disk rotates between two spring copper blades. Standard finishes, bronze or black; other colors available. Sufficient knockouts in cabinet to meet all installations. Square D Company, Detroit, Mich.



■

Fire Hose

Manufactured flat, becoming round only when filled with water. Claimed by the manufacturer are low resistance to the flow of water; ease of coiling and racking; minimum tension when coiled. B. F. Goodrich Co., Akron, Ohio.

■

Casters

Pressed steel swivel and stationary casters, fitted with semi-steel and solid rubber wheels, with self-lubricating bushings. Tread of the solid rubber wheels may be soft or hard. Bond Foundry and Machine Co., Manheim, Pa.

TRADE LITERATURE—December

For copies, address the manufacturers concerned

■

(316) MOTORS—Folder 1104-1; shaded pole type midget motors.—Barber-Colman Co., Rockford, Ill.

(317) ROOFS—Folder M-10-5M-9-32, 4 pages; "Ferrocoustic" Roofdecks.—Truscon Steel Co., Youngstown, Ohio.

(318) CENTRIFUGAL PUMPS—Bulletin W-323-B1, 4 pages; construction and application of a line of centrifugal pumps equipped with "Hytor" priming unit.—Worthington Pump and Machinery Corp., Worthington Ave. at Warren St., Harrison, N. J.

(319) MOTORS—Folder F 1222; four-pole unidirectional midget motors.—Barber-Colman Co., Rockford, Ill.

(320) PUMPS—vertical rotating shaft type—Bulletin D-450-S9, 4 pages, covering wells up to 6 inches; Bulletin D-450-S10, 4 pages, covering, 6-, 8-, and 10-in. wells; Bulletin D-450-S11, 4 pages, covering 12-, 14-, 16-, and 20-in. wells.—Worthington Pump and Machinery Corp., Worthington Ave. at Warren St., Harrison, N. J.

(321) DRINKING WATER — Booklet, 16 pages, "Cool Water and Your Profits." A report of a nation-wide study of offices and industrial plants, analyzing the effect of proper water supply on the productivity of workers.—Kelvinator Corp., Detroit, Mich.

(322) MECHANICAL PACKING—Handbook, 36 pages, industrial packing. Also actual samples of thirty-six different materials.—Felt Products Manufacturing Co., 1508 Carroll Ave., Chicago, Ill.

(323) PUMPS — Catalog B-6, 4 pages, propeller pumps.—De Laval Steam Turbine Co., Trenton, N. J.

(324) STEAM TRAPS—Manual on steam trap engineering, also information on the complete line of traps made by this company.—Armstrong Machine Works, Three Rivers, Mich.

(325) VALVES — Catalog 5, 48 pages; complete line of forged brass valves and fittings for mechanical refrigeration service.—Kerotest Manufacturing Co., 2525 Liberty Ave., Pittsburgh, Pa.

(326) MOTORS—Leaflet F1221; two-pole undirectional midget motors.—Barber-Colman Co., Rockford, Ill.

(327) LUBRICATION—Bulletin, 8 pages; "Bottle Oilers—Their Construction, Operation and Application."—The Lunkenheimer Co., Cincinnati, Ohio.

(328) SLINGS—Catalog, Sixth Edition, 86 pages; "Wire Rope Slings".—John A. Roebling's Sons Co ., Trenton, N. J.

(329) PAINT—Bulletin 20, "Rust—Cause and Prevention". — American Chemical Paint Co., Ambler, Pa.

(330) AIR CONDITIONING—Folder, 4 pages; Jefferson "Ozonator"; Jefferson Electric Co., Bellwood, Ill.

(331) LUBRICATION—Technical Bulletin 102.3; "The Lubrication of Small Mechanical Devices".—Acheson Oildag Co., Port Huron, Mich.

(332) METERS—Bulletin, 24 pages; a new line of fluid meters.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

(333) POWER TRANSMISSION—Condensed catalog 105, 32 pages; cog-belt drives.—The Dayton Rubber Manufacturing Co., Dayton, Ohio.

(334) FITTINGS—Bulletin 1002, 32 pages; malleable iron, explosion resisting fittings for use in hazardous locations.—Appleton Electric Co., 1701 Wellington Ave., Chicago, Ill.

(335) CHART—Parallel resistor chart which eliminates calculations arising from the use of resistors in parallel.—Ohmite Manufacturing Co., 636 N. Albany Ave., Chicago, Ill.

(336) POWER TRANSMISSION—Catalog B-200, 12 pages. Engineering data and photographs of typical installations of "Vari-Speed" motor pulleys.—Reeves Pulley Co., Columbus, Ind.

(337) STAINLESS STEEL — Folder, 4 pages; "Use of Stainless Steel in the Dyeing Industry".—Electro Metallurgical Co., 30 East 42 St., New York, N. Y.

(338) WELDING ROD—Booklet, 20 pages; "Oxweld No. 25 M Bronze Patented Welding Rod."—The Linde Air Products Co., 205 East 42 St., New York, N. Y.

(339) IMMERSION HEATERS — Leaflet, TB-30; electric immersion units for heating oil.—Harold E. Trent Co., 618 N. 54 St., Philadelphia, Pa.

(340) NUTS AND BOLTS—Catalog, data regarding heads, threads, weights, with several pages of illustrations showing special and odd-shaped bolts. Clark Bros. Bolt Co., Milldale, Conn.

(341) DIESEL ENGINE—Form 1683, 22 pages; design and construction details of the Caterpillar diesel engine.—Caterpillar Tractor Co., Peoria, Ill.

(342) MOTORS—Leaflet F 1223; two-pole reversing midget motors.—Barber-Colman Co., Rockford, Ill.

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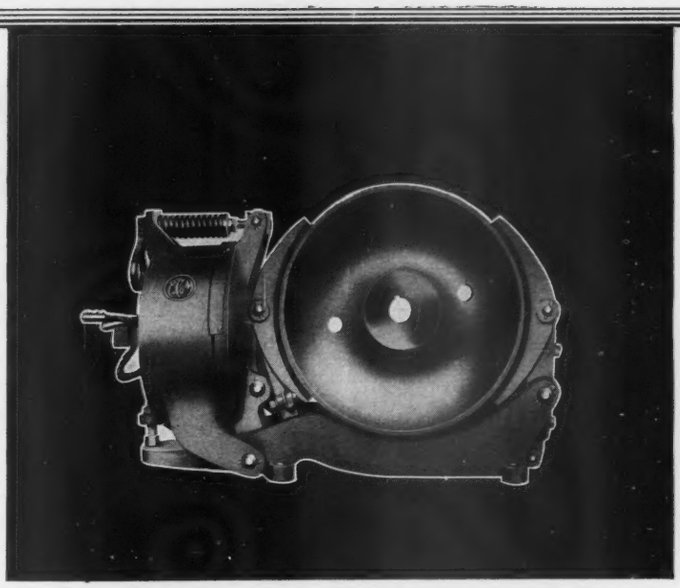


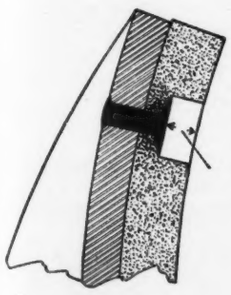
a good brake never wears out

5 Industrial Plants report

their upkeep costs on EC&M Type WB Brakes

THESE facts are the actual repair part costs of EC&M Type WB Brakes in five plants for a period of five years. Three of the plants are steel mills, one a locomotive manufacturing plant and the other a foundry and large machine shop where heavy duty machinery is built.

In addition to the severe service normally encountered in these types of plants over one-half the total number of these Type WB Brakes are used on applications where either the crane hoist motions are equipped with only plain reversing control or the motors and drives are equipped with anti-friction bearings. This means these WB Brakes are aided very little by frictional braking in the one case and in the other case are not assisted by dynamic braking in bringing the loads to rest.



Actual wearing thickness, between rivet heads and brake wheel, is ⅛" on the smallest size to ½" on the largest size.

"—a good brake never wears out." Note how closely EC&M Type WB Brakes approach this ideal condition— *the average maintenance cost of repair parts per brake per year for these brakes is but 73/100 of 1 per cent of the original cost. And although more than one-third of these brakes have been in service since 1928 or before, only 44 brakes have required reblocking. Such slow wear means infrequent adjustment.

HERE ARE THE FACTS OF FIVE YEARS OPERATION—

Total number of brakes in these 5 plants	307
Average length of service of each brake	2¼ yrs.
Cost of repair parts per brake per year	$1.75
Average maintenance cost per brake per year*	0.73%

Only 44 of these brakes have required reblocking.

THE ELECTRIC CONTROLLER & MFG. CO.
CLEVELAND, OHIO

THE ELECTRIC CONTROLLER & MFG. CO.
2700 East 79th St.,
Cleveland, Ohio

Gentlemen:

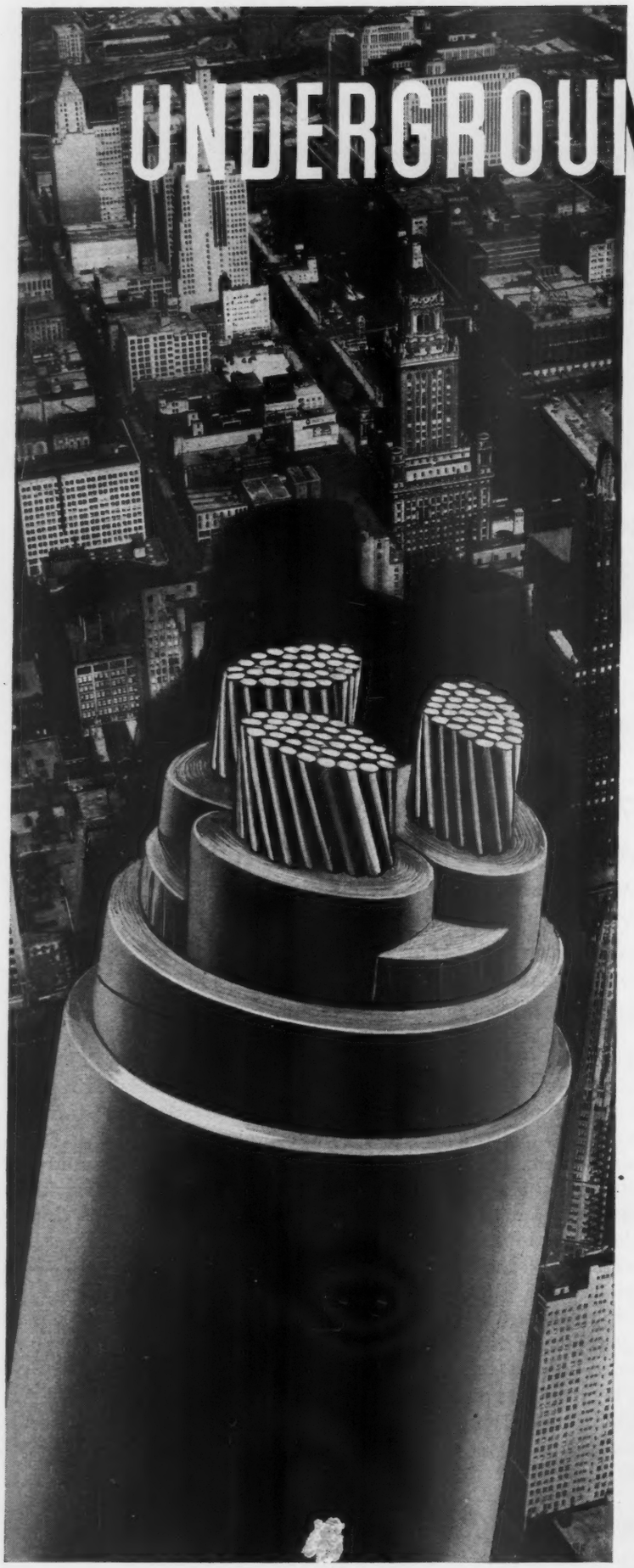
Please send me your WB Brake Bulletin 1004-A ☐

Please show me the upkeep costs you have ☐

Name .....

Company .....

Address .....



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IF you are unacquainted with these high quality cables, we would welcome an opportunity to show them to you. Samples from current orders would gladly be sent on request—and we are certain that their obviously fine workmanship would impress you.

Roebling Paper Insulated Cables are made to traditional exacting Roebling standards and meet all the specification requirements of the N.E.L.A. and the Association of Edison Illuminating Companies. They are available in unshielded or Type H constructions, single or multiple conductor.

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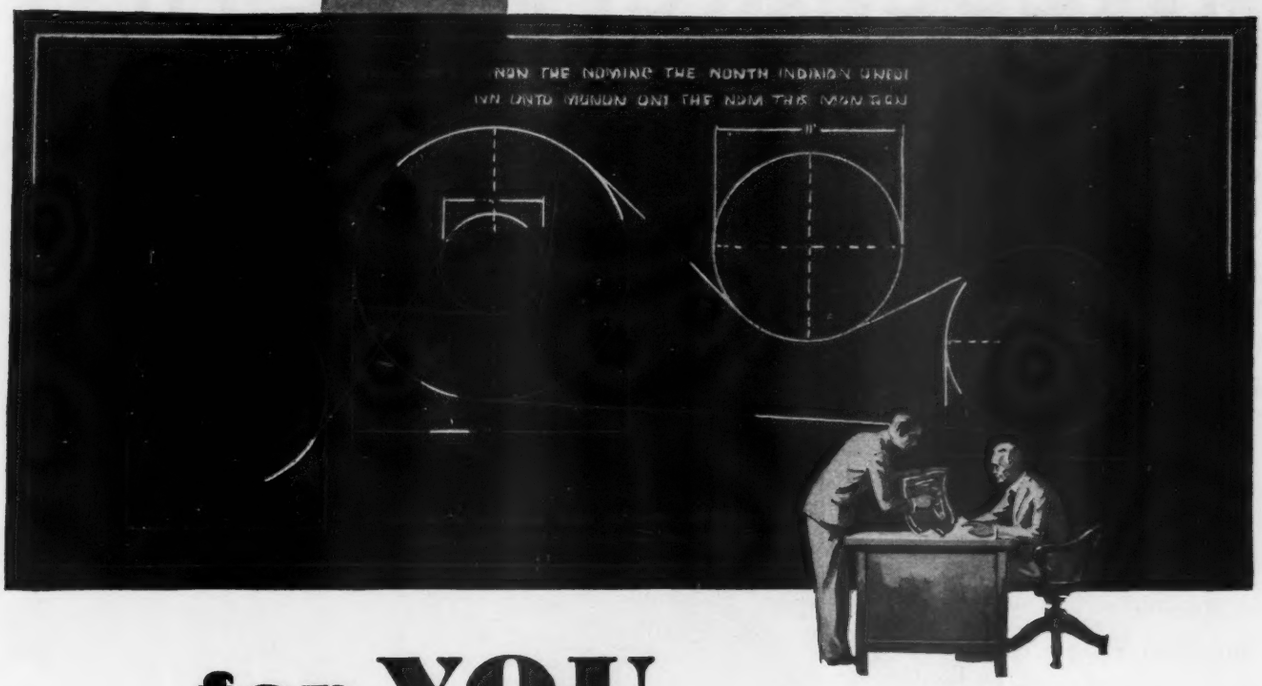
A MAN with an IDEA



for YOU

He has brought money-making and money-saving ideas to owners and operators of many industrial plants all over the world, has the G. T. M. — Goodyear Technical Man.

His specialty is rubber, as applied to power transmission, conveying, elevating, bigger work, faster work, cleaner work in thousands of plants and scores of industries. He is an expert on rubber, with a practical knowledge of operating conditions in many industries.

Here on this page you see suggested typical operations in which G.T.M.-specified Goodyear Mechanical Rubber Goods are delivering better service, more trouble-free service, at lower cost—which, after all, sums up to more profit in any operation.

In the cases illustrated, and in many, many more, the G.T.M., functioning on the Goodyear Plant Analysis Plan, contributed a sound, scientific idea which meant money to the owner or operator.

Might he not do as much for you? Then why not get in touch with him? A line, or a call, to Goodyear, Akron, Ohio, or Los Angeles, California, will bring the G.T.M.

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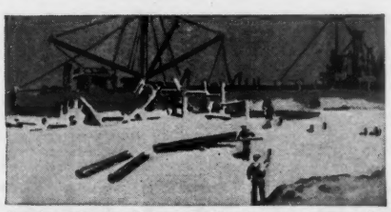

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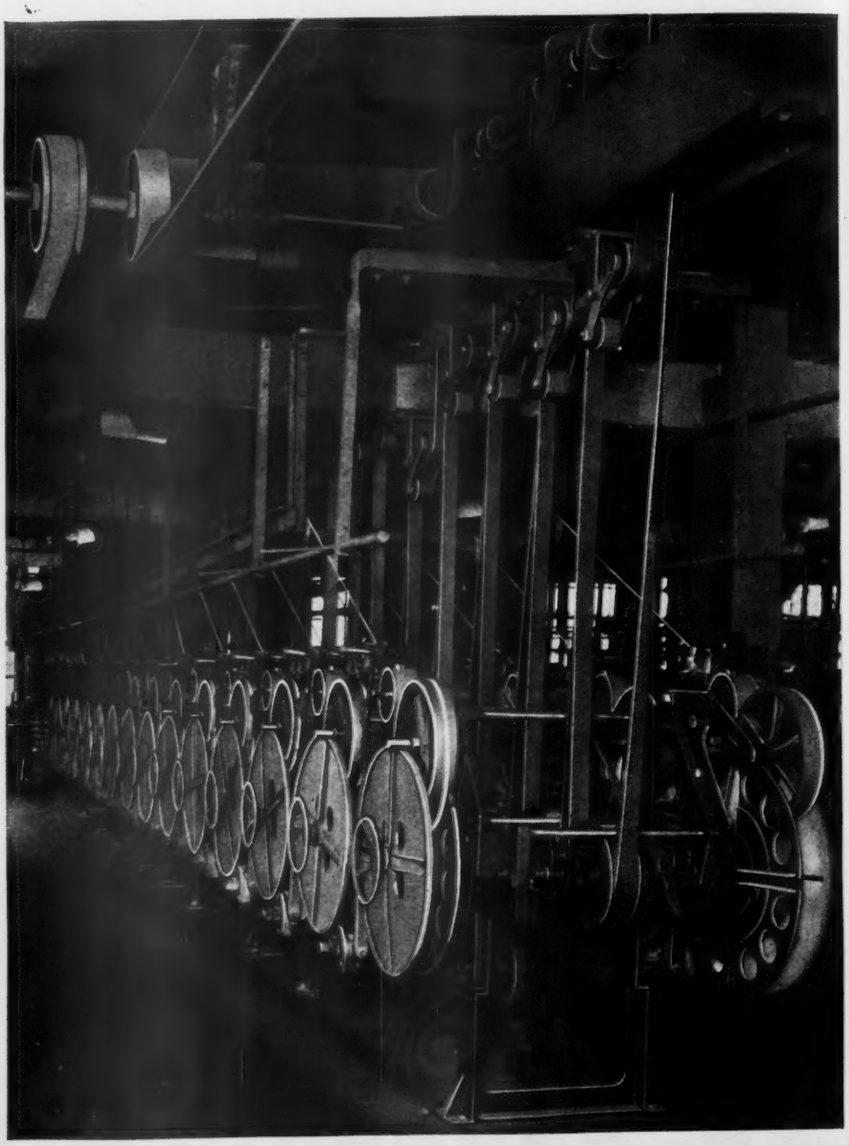
All Goodyear products are constantly under development and test for further improvement. Each new advance is completely mill- or mine-proved when offered for industrial service

The very largest coal conveying operations in this country are done on Goodyear Conveyor Belts. These belts, scientifically designed, constructed and applied to their work, have a record for outlasting others by as much as millions more tons carried and years more of service

RESEARCH BELTING



GRATON & KNIGHT

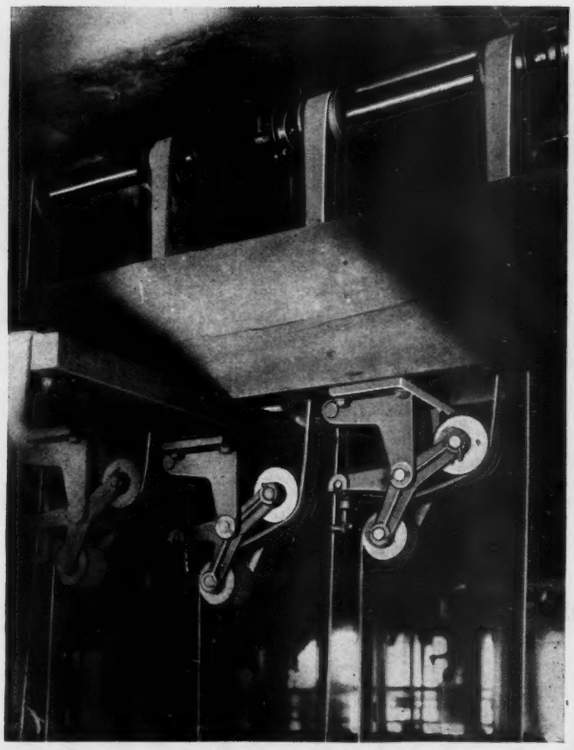
* RESEARCH

LEATHER BELTING

definitely lowers maintenance and production costs . . .

INSTALLATIONS such as this, on a flat wire coiling machine, conclusively prove our engineering department's claims for the new Research Belting.

The photographs show what an unusual and difficult drive problem it is, with a quarter turn and two right angle turns in each 28 foot belt. Furthermore, there are 30 belts to each machine, 160 in all in this plant . . . plenty of opportunity for weak sisters to show up.



But there have been no weak sisters. Research Belting has handled this difficult job to the entire satisfaction of the plant superintendent and the secretary of the Company alike. Performance is excellent. Costs are low.

Similarly, Research Belting is definitely lowering maintenance and production costs in hundreds of other plants. Not theoretical savings, but actual savings brought about by **75% less stretch; new type friction surface** that delivers full power with low bearing pressure; greater **flexibility** and **15% greater strength** that mean longer belt life under all conditions.

These performance-proved advantages are available in the entire Graton & Knight line of Leather Belting.

Have our local Power Transmission Man show you actual performance data and analyze the possibilities for savings in your own plant. Research Belting performance is now a matter of record. Graton & Knight Company, Worcester, Massachusetts.

GRATON AND KNIGHT

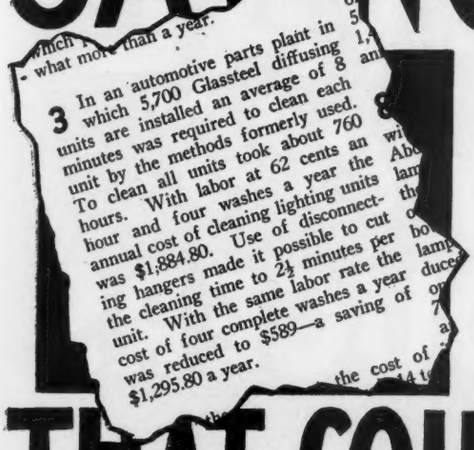
HUNDREDS of industrial men have returned to their plants, after a visit to General Electric factories, convinced that the answer to almost any fabrication problem is already in the arc-welding-engineering files of the General Electric Company — convinced that all the arc-welding equipment they might need can be obtained on one order blank from one dependable manufacturer.

That's why so many instinctively turn to the nearest G-E office for every arc-welding requirement.

530-127

GENERAL ELECTRIC

SAVINGS THAT COUNT


3 In an automotive parts plant in which 5,700 Glassteel diffusing units are installed an average of 8 minutes was required to clean each unit by the methods formerly used. To clean all units took about 760 hours. With labor at 62 cents an hour and four washes a year the annual cost of cleaning lighting units was $1,884.80. Use of disconnecting hangers made it possible to cut the cleaning time to 2½ minutes per unit. With the same labor rate the cost of four complete washes a year was reduced to $589—a saving of $1,295.80 a year.

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The above, clipped from the September issue of Maintenance Engineering, is one of many records of important, worthwhile savings made by using lamp lowering hangers.

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Thompson Lamp Lowering Hangers reap *all* the benefit of the lamp lowering principle. They are economical in first cost, long lasting, safe, easily operated, convenient.

They are simple and easy to wire. Reflectors may be interchanged without disturbing electrical connections.

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"Why doesn't flameproof wire work?"

Ice is flameproof. It won't burn. But it won't last long at temperatures above 32°F. A flameproof wire is not necessarily heatproof but a genuine heatproof wire is always flameproof.

That's the question we're asked right along by puzzled engineers.

Rubber wire in hot places fails—they put in flameproof wire ("Because that's the stuff for hot places, isn't it?") and it too, fails, and then they don't know where they're at.

Flameproof wire can be any kind of wire with a flameproof paint finish. It will not burn under a momentary exposure to flame. It was intended to be used in places where a fire hazard existed, but it is of no more use in locations where high temperatures exist than any ordinary wire.

In hot spots—boiler rooms, around motor operated steam valves, steel mills, furnaces, soaking pits, resistors, ash alleys—what is needed is, not flameproof, but genuine *heatproof* wiring.

The ROCKBESTOS line of wires, cables and flexible cords is real heatproof wire. Its heatproof construction does not stop at the braid but goes right through to the copper. The insulation does not grow hard and crack with heat or from age—remains always as flexible and resilient as the day it was formed.

Specify ROCKBESTOS for all wiring where the slightest suspicion of high temperatures exists or where wiring is exposed to other types of severe conditions.

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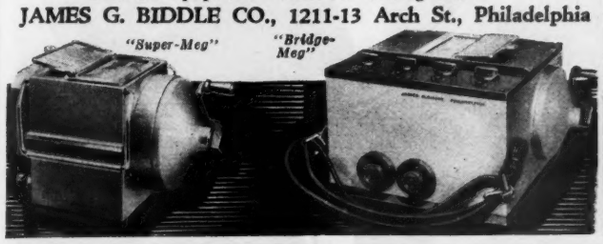

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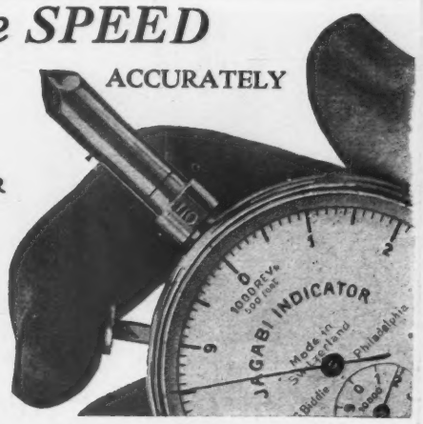

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M.E. 12/32

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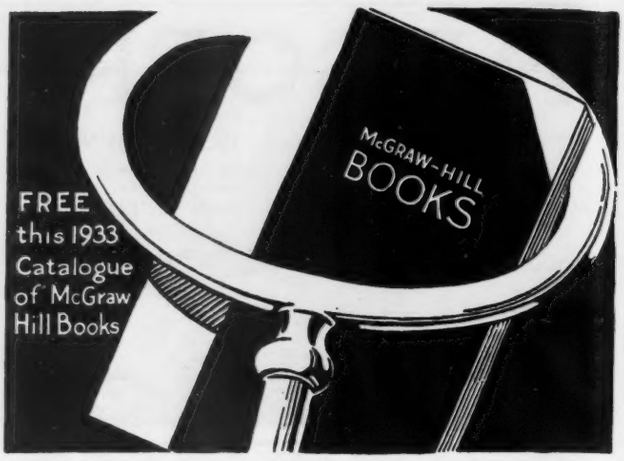

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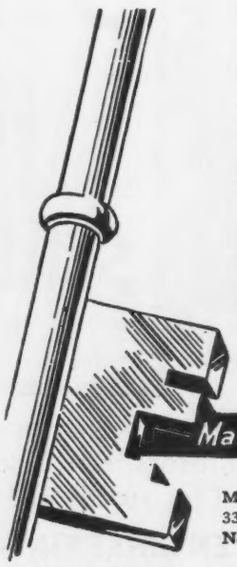

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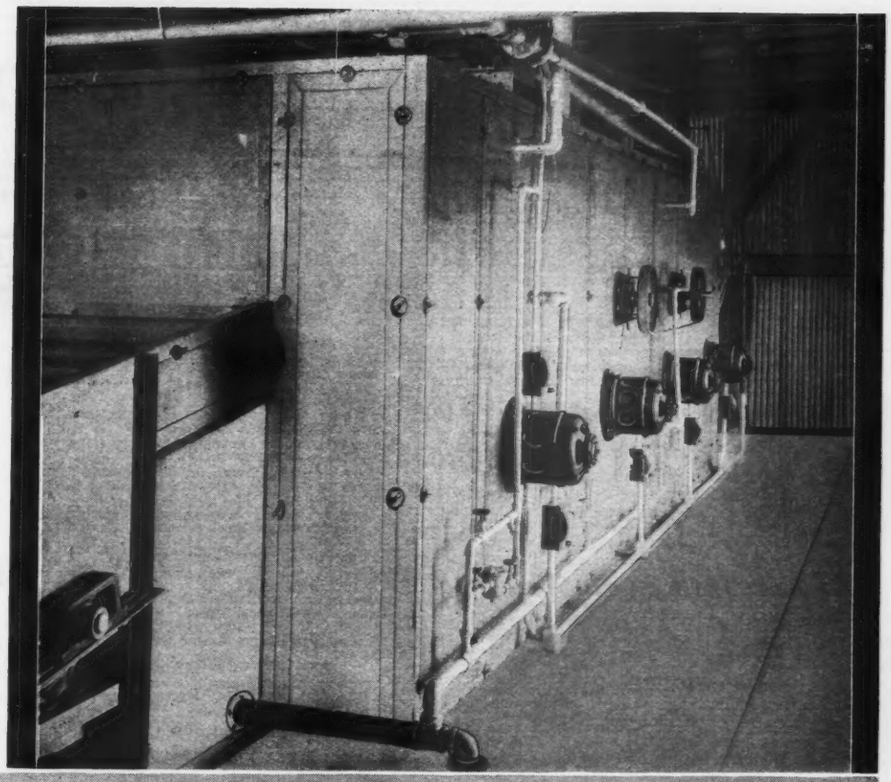

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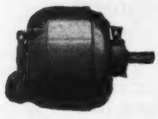
Totally Enclosed Chemical Plant Motor—Roller Bearing

Flange Type Motor Roller Bearing

Vertical Ring Base Motor Roller Bearing



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Electrical Division of

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220	220 440	G.E.	450
200	440 220	G.E.	600
150	2200-440 220	G.E.	514
150	220 440-550	G.E.	600
150	220 440	G.E.	720
125	220 440	G.E.	1800
100	550	Westghse.	900
100	2200	Westghse.	900
100	550	G.E.	720
100	440-220	G.E.	720
75	440-220	G.E.	600
60	440-220	G.E.	720

DIRECT CURRENT MOTORS

Hp.	Volts	Speed	Make	Type
100	230	1150	G.E.	LC
100	230	625	Westghse.	SK
80	230	600	G.E.	RC
75	230	950	G.E.	RC
50	115	565	G.E.	DLC
40	230	750	G.E.	RC

DIRECT CURRENT GENERATORS

Kw.	Volts	Speed	Make	Type
225	250	900	G.E.	MPC
100	250	725	Westghse.	SK
75	250	750	G.E.	RC
50	125	725	G.E.	DLC
40	250	850	G.E.	RC

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1—200-kw., 230-V., 3-ph., 60-cy., 2300-4100-V., Synchronous Motor Generator Set.
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1—150-kw., 600-r.p.m., 250-V Gen., 3-ph., 60-cy., 220-440-V. G. E. Synchronous Motor.
1—125-kw., 250-V., Westinghouse Synchronous Generator Motor Set, 3-ph., 60-cy., 230-2200-V.
1—100-kw., 125-V., D.C., 220-240-V., A.C. G.E. Synchronous Motor Generator Set.
1—100-kw. 250-V., Gen., 900-r.p.m., 2200-V. Synchronous Motor.
1—50-kw., 230-V., 1200-r.p.m., 220-V. Westinghouse Synchronous Motor.
2—50-kw., 125-V. 1200-r.p.m., 220-V. Westinghouse Synchronous Motor.

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1—475-kva. Westinghouse Non-condensing.
1—75-kva., 3-ph., 60-cy. Westinghouse Geared Non-Condensing Turbine.

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1—1500/3000-kva. G. E., combined oil and water cooled 3-ph., 60-cy., 11000-22000-2300-V.
4—333-kva. Pittsburgh, 4100/110/220-V.
3—200-kva. G. E., 2400/120/240-V.
4—150-kva. Westinghouse, 2400/120/240-V.
3—100-kva. Westinghouse, 2400/120/240-V.

A. C. GENERATORS

No	Kw.	R.p.m.	Volts	Ph.	Type
1	400	900	2300–4000	3	Westg.
1	350	600	440	3	Westg.
2	125	900	2300	3	Cr.-Wh.
2	100	900	230–2300	3	G.E.
1	75	600	220	3	Westg.
1	75	900	2300	3	G.E.
1	50	1200	220–440–2300	3	G.E.

MOTORS — 3-Phase, 60-Cycle

No.	Hp.	R.p.m.	Volts	Type
1	500	900	440/4000	Westghse. syn.
1	500	900	400–2200	G. E. syn.
1	350	900	2200/4000	Wh. syn.
2	300	600	445–2300	G. E. syn.
1	250	600	2200/4000	G. E. syn.
1	250	600	220–440	Westg. syn.
1	250	600	440–2200	G. E. syn.
3	200	514	4150–2300	G. E. syn.
2	175	3-ph.	60-cy.	2300-volts, G.E.
4	150	1200	220/440	Westg., sl. rg.
1	150	900	2200	G. E. syn.
2	150	514	2200	Westg. sl. rg.
1	150	1800	2200	West. sq.cg. mtr.
1	100	900	440/2200	G. E. sq. cg.
1	100	900	220–440–220	Westg. sq. cg.

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Continued from preceding page

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200-hp. West. Slip Ring, 440/220 v., 500 r.p.m.
200-hp. G.E. Synch., 2200/440 v., 514 r.p.m.

MOTOR GENERATOR SETS

100 kw. G.E., 3 bearing, D.C., RC, 250/125 v.; A.C., 150 hp. Slip Ring, 220/440 v., 3 ph., 60 cy., 1175 r.p.m. Complete.
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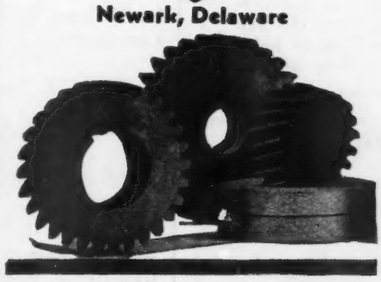

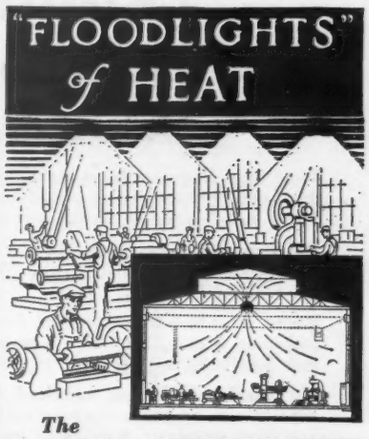

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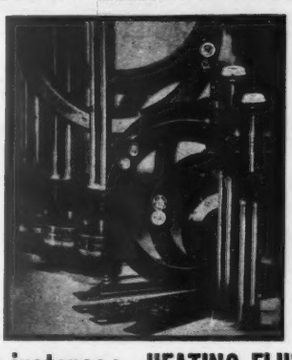

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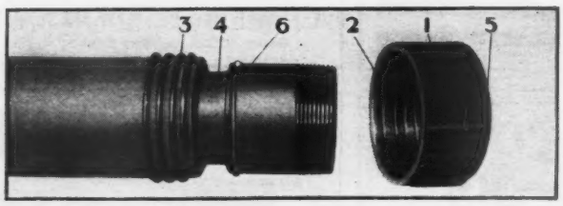
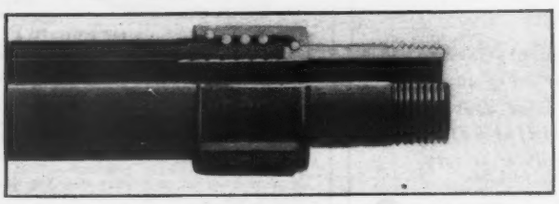


The Wil-Bro "Clamp" is a compression collar (1) with a special inner groove (2) that "seats" on a coiled wire (3)—producing a firm uniform pressure on the full circumference of the hose. It doesn't just "bite" in at a few points. This uniform pressure permits a thin walled insert (4)—and results in maximum unrestricted flow and greatest operating efficiency. A flange (5) on the end of the clamp engages a shoulder (6) on the coupling insert—thus doubly assuring positive hose attachment.

Get all the facts on Wil-Bro Couplings Now. Send for Catalog No. 103.



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88 Second Street, San Francisco

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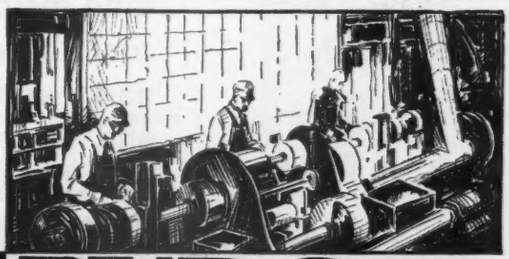

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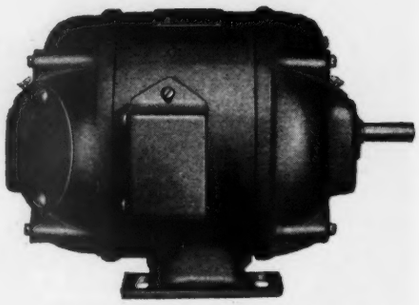

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For more than 28 years Century Motors have been giving continuously satisfactory service in many hundred thousand installations in all parts of the world . . . They have contributed much toward reducing production, maintenance and service costs—both in direct plant applications and when used by the many manufacturers of motor-driven apparatus who know the sales value of equipping their product with motors of proved reliability and long life.

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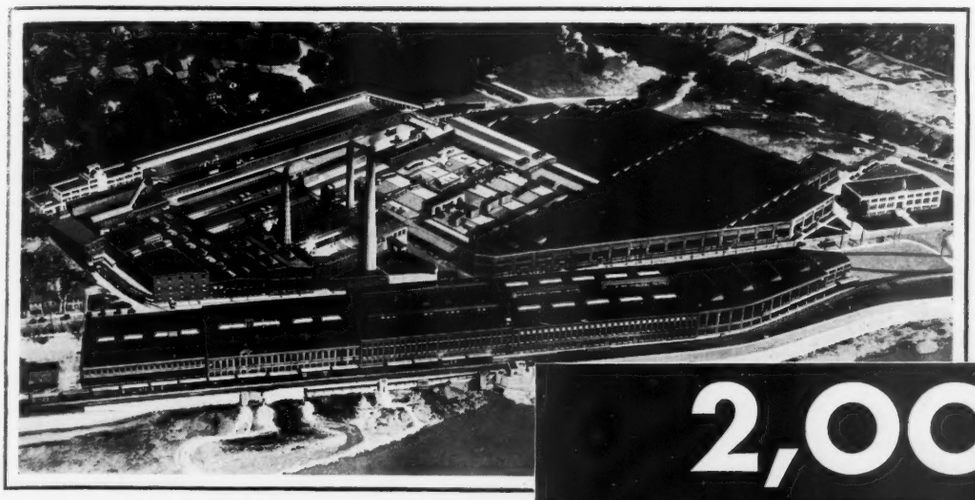
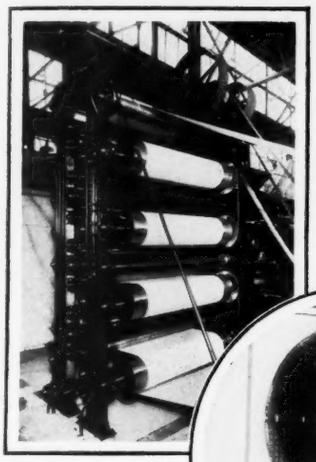
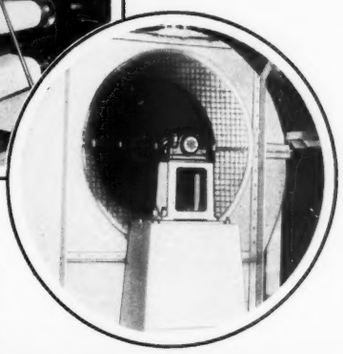


Mills of the Champion Coated Paper Company at Hamilton, Ohio. Dodge-Timken Bearings are being used after repeated tests proved their efficiency.

2,000 DODGE-TIMKEN BEARINGS CUT COSTS FOR CHAMPION!



Special Brushing machine at the Champion plant, equipped with 80 Dodge-Timken Bearings.



The operation of this Forced Draft Fan is entirely dependent on Dodge-Timken Bearings. Failure of one of these bearings would mean a serious interruption to production.

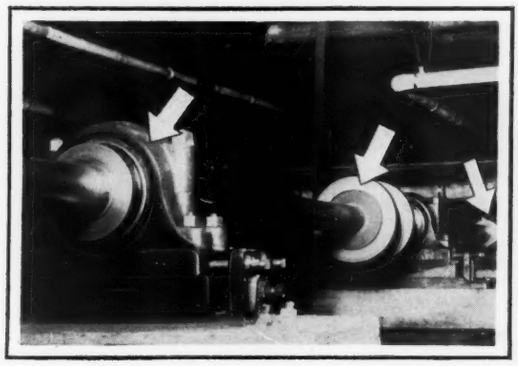
IN THE MODERN MILL of The Champion Coated Paper Company at Hamilton, Ohio, more than 2,000 Dodge-Timken Bearings are busily at work cutting power and maintenance costs.

Champion's decision to standardize on Dodge-Timkens came after exhaustive plant tests and a thorough study of the whole bearing problem.

For example, a supercalender was equipped with Dodge-Timkens and careful records kept on performance. These tests showed a saving of 50% in power consumption and an increased production of 37½%, to say nothing of lowered maintenance costs. On the basis of this record, 10 additional supercalenders were Dodge-Timken equipped.

Similarly, Dodge-Timken equipment has won its way throughout the plant. On line and countershafts, pebble mills, coating machines, fourdriniers, brushing machines, fans and other paper making machines where strenuous service wreak heavy toll on old style bearings — Dodge-Timken bearings supplied the answer to economy and efficiency.

Champion's experience is typical of many plants in many fields where Dodge-Timken bearings and Dodge power drive units have been selected after definitely proved ability to cut operating and maintenance costs. Dodge experience and facilities are at your service to show you how these same advantages can be secured for your plant.



Variable Speed Line Shaft of one of the Champion Paper Machines. This shaft has seen years of service with no attention except infrequent lubrication.

Cut Costs in 1932 with modern Industrial POWER DRIVE and Bearing UNITS by DODGE

Definite recommendations from the same engineering staff, whose suggestions have been welcomed by so many plant executives, are yours for the asking. Whatever your power drive problem may be — Dodge experience and facilities can help you find the answer.

Write us for complete information and interesting book — "Operating Economies for 1932."

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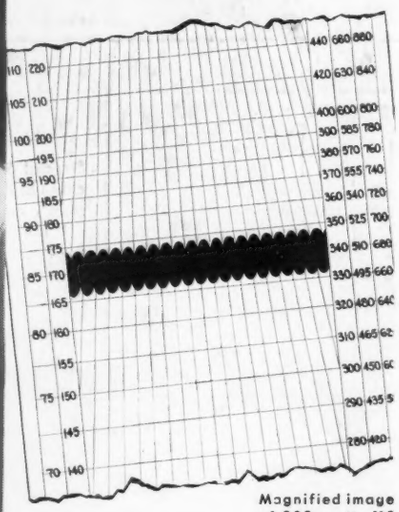
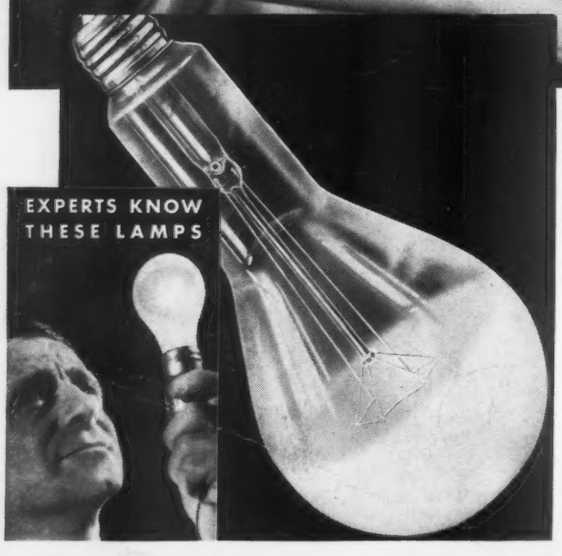
Tiny Filament coils . . . magnified 50 times . . . are critically inspected for "turns per inch"

Magnifying Projectoscope checks every Hygrade lamp filament. The enlarged image is shown in the diagram.



Magnified image of 200 watt, 115 volt PS-30 filament.



MAKING quality lamp bulbs — bulbs that are uniform and "standard" in every respect — means almost unbelievable exactness. Every process of manufacture and testing must be carried out with the help of trained workers . . skilled engineers . . the last word in modern machinery.

You find all these things at the Hygrade plant. The magnifying projectoscope shown above . . . delicate torsion balances . . . powerful microscopes . . . painstaking electrical tests . . . all play a part in making Hygrade Lamps second to none in quality!

Hygrade Lamps pass the exacting requirements of the United States Government. They actually give you more light for your money. When you buy them you save current cost . . . and save up-keep cost. That's why they are used by many of the country's most important industries.

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